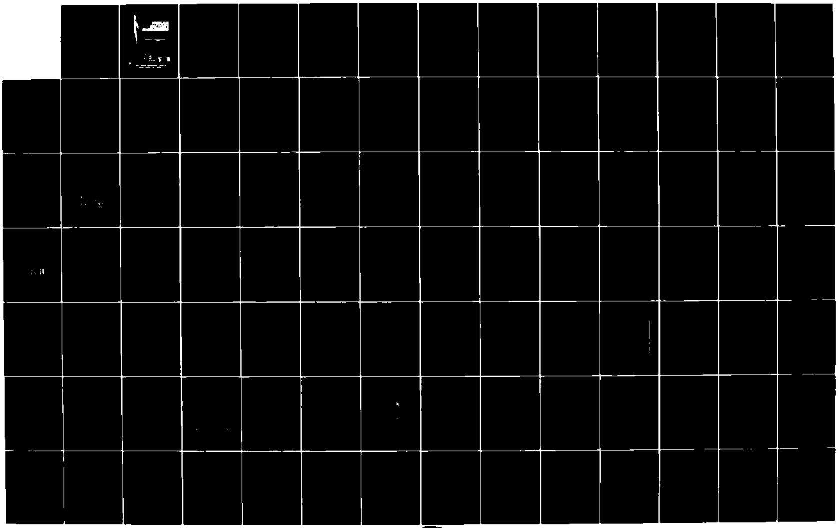
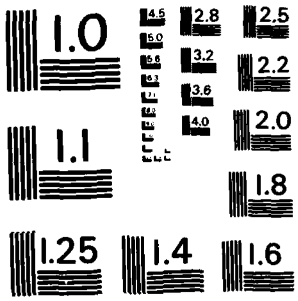
AD A132 555 HUMAN FACTORS ENGINEERING STUDENT SUPPLEMENT(U) HUMAN ENGINEERING LAB ABERDEEN PROVING GROUND MD R BROGAN ET AL. AUG 81 1/2

UNCLASSIFIED F/G 5/5 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Approved for Public Release:
Distribution Unlimited

HUMAN FACTORS ENGINEERING

STUDENT SUPPLEMENT

Ruth Brogan
Jerry Hedge
Kevin McElroy
Judah Katznelson

August 1981

Approved for Public Release:
Distribution Unlimited

U.S. ARMY HUMAN ENGINEERING LABORATORY
PACIFIC MISSILE TEST CENTER

PREFACE

This text is intended for use with either the computer-aided or self-paced versions of ~~your~~ the course on Human Factors Engineering. The supplement is divided into the same 40 sections or lessons as ~~your~~ the course text. In each supplemental lesson ~~you will find~~ there is an outline of the course lesson as well as tables, figures, and/or articles which are to be used with each lesson.

We hope you both enjoy and learn from these lessons. Good Luck.

ACKNOWLEDGEMENT

Grateful acknowledgement is made to the following persons who provided much technical support:

John Miles, U.S. Army Human Engineering Laboratory
Lt. Alex Bory, Pacific Missile Test Center
Martha Kinney, Advanced Technology, Inc.
Paul Dumas, Advanced Technology, Inc.

TABLE OF CONTENTS

Page

SECTION II: HOW THE HUMAN FITS INTO THE SYSTEM

LESSONS:

LESSON 1: WELCOME TO HUMAN FACTORS ENGINEERING

This lesson provides you, the student, with an explanation of computer-aided or self-paced instruction and how to use the materials presented to you. Also in this lesson, you will be told what military documentation is needed both for this course and for use in your job as a human factors specialist.

This course is divided into three major sections. Section I deals with the human's capabilities and limitations. In this section, the history and continued need for human factors engineering will be investigated. Lessons 6-10 are concerned with the physiological capabilities and limitations of human beings. In lessons 11-13, you will learn how the proper design of controls and displays makes use of the information learned in the previous lessons. Lessons 14-19 take a look at the human being as he interacts with his environment, followed by a review of the first section in lesson 20.

The primary focus of Section II is upon the human as he fits into the system. In lessons 21-27, you will be investigating the role of the human engineer in various aspects of analysis, such as systems analysis, cost analysis, task analysis, etc. Lessons 28-29 are concerned with the selection and training of personnel. In lessons 30-34, you will receive a short course on experimental techniques and statistical concepts. Finally, lesson 35 will offer a review of Section II.

Section III is entitled "Human Factors in the Military." In this section, lessons 36 and 37 focus on human factors organizations, documentation, and future applications.

To give you, the student, a practical application of what has been presented in the course, lessons 38 and 39 will ask you to work on a 'real world' problem. To complete successfully these lessons, you will need to rely upon your experience with lessons 1-37. Finally, in lesson 40, a more typical review of the entire course is presented.

TERMINAL OBJECTIVES:

Upon completion of the Human Factors Engineering Course, the student will demonstrate the following capabilities and knowledge:

1. An understanding of common terms used in human factors engineering.

2. A familiarity with human factors references and an ability to use them.

3. An awareness of potential sources of technical information on major human factors topics.

4. An understanding of the goals of human factors engineering in a material development program.

5. An ability to integrate human factors principles in a DoD sponsored program.

6. An ability to determine human performance requirements in a systems concept.

7. An understanding of the kinds of factors and forces which affect human performance and an ability to identify and measure them.

8. An awareness of the differences between field and laboratory measurements.

9. An awareness of what "experimental control" measures are necessary for any test involving human performance and the effects in their absence.

10. An understanding of basic statistical techniques, such as analysis of variance.

11. An ability to calculate human performance reliability.

12. An ability to formulate performance measures for the dependent variables of time and error.

13. An ability to analyze human performance data within the context of "system effectiveness" and "system reliability."

14. An understanding of the major techniques used by human factors specialists during system synthesis, design, and development.

15. A familiarity with task analyses.

16. An awareness of the relationship between human factors engineering and the engineering specialists of reliability, maintainability, and safety.

17. An ability to interpret and apply the standards and specifications of the human factors engineering community.

READING

LESSON 1: PSYCHOLOGY AND THE DESIGN OF MACHINES

Franklin V. Taylor

Psychologists have been helping engineers design machines for more than fifteen years. It all began during World War II with the rapid development of radars, sonars, aircraft control systems, and other similar devices. Previous to this time, the only role played by psychologists relative to military mechanisms was that of doing research and giving advice on the selection and training of the operators. However, very early in the war, it became apparent that these Procrustean attempts to fit the man to the machine were not enough. Regardless of how much he could be stretched by training or pared down through selection, there were still many military equipments which the man just could not be moulded to fit. They required him too many hands, too many feet, or in the case of some of the more complex devices, too many heads.

Sometimes they called for the operator to see targets which were close to invisible, or to understand speech in the presence of deafening noise, to track simultaneously in three coordinates with the two hands, to solve in analogue form complex differential equations, or to consider large amounts of information and to reach life-and-death decisions in split seconds and with no hope of another try. Of course the man often failed in one or another of these tasks. As a result, bombs and bullets often missed their mark, planes crashed, friendly ships were fired upon and sunk. Whales were depth-charged.

Because of these "human errors," as they were called, psychologists were asked to help the engineers produce machines which required less of the man and which, at the same time, exploited his special abilities. The story of what happened is sufficiently well known not to require any lengthy retelling here. In brief, the psychologists went to work, and with the help of anatomists, physiologists, and, of course, engineers, they started a new inter-discipline aimed at better machine design and called variously human engineering, biomechanics, psychotechnology, or engineering psychology. The new field has developed rapidly in the seventeen or eighteen years of its existence, and it has now attained sufficient respectability to be accorded divisional status by the American Psychological Association. At the last meeting of the Council of Representatives, authorization was given for the founding of The Society of Engineering Psychologists as Division 21 of the APA.

It seems fitting, now that engineering psychology has been recognized as a viable entity, that we examine this new field to find out just what it is that psychology is doing for the design of machines. It is probably even more necessary that we also inquire into what the participation in the design of machines is doing for, or to, psychology. Many young people are being lured into human engineering by the abundant opportunities provided for advancement and the tantalizing salaries offered by commercial organizations. It has been suggested by an unassailable authority that a major breakthrough in the field of psychology in recent years has been the psycholgists' discovery of money. It may be remarked that it was undoubtedly an engineering psychologist who first got wind of the find.

In all seriousness, however, psychologists who might otherwise conduct basic research may be attracted into this new applied area, and it is therefore important to know what it represents professionally and scientifically in order to evaluate its threat, or its promise. To decide what actions to take relative to encouraging the further development of the field, answers are needed to questions such as the following: To what extent is engineering psychology engineering, to what extent is it psychology, and to what extent is it neither? Is it a fruitful scientific area? Is it, indeed, a scientific area at all?

In the attempt to provide answers to these questions, let us look at psychologists caught in the act, so to speak, of doing human engineering. However, before we can meaningfully analyze the behavior of engineering psychologists, the concept of the man-machine system must be described. Human engineers have for some time now looked upon the man and the machine which he operated as interacting parts of one overall system. In figure 2.1 (on the following page) is shown a paradigm of the concept. This may be viewed as a radar device, a pilot-aircraft control system, a submachine diving control station, the captain's station on the bridge of his ship, or, in fact, any man-machine system at all.

In essence, it represents the human operator as an organic data transmission and processing link inserted between the mechanical or electronic displays and controls of a machine. An input of some type is transformed by the mechanisms into a signal which appears on a display. Perhaps it is shown as a pointer reading, a pattern of lights, or a pip on a cathode ray tube. However it appears, the presented information is read by the operator, processed mentally, and transformed into control responses. Switches are thrown, buttons are pushed, or force is applied in a joy stick. The control signal, after transformation by the mechanisms, becomes the system output, and in some devices it acts upon the displays as well. These latter are called "closed-loop" systems in contrast to "open-loop" systems wherein the displays do not reflect the human's response.

When the man and the machine are considered in this fashion, it immediately becomes obvious that, in order to design properly the mechanical components, the characteristics of the man and his role in the system must be taken into full account. Human engineering seeks to do this and to provide as much assistance to the system designer as possible. Specifically, the psychologist tries to help his engineering colleague in three different ways. First of all, he studies the psychology of the human as a system component. Second, he assists the engineer in experimentally evaluating prototype man-machine systems. Finally, he teams up with engineers to participate actively in the design of machines. Each of these human engineering functions will be described in turn, beginning with the last and the least scientific activity.[1]

[1]The preceding was adapted from American Psychologist, 12, 1957, 249-258.

LESSON 2: WHY HUMAN FACTORS?

This lesson introduces you to the man/machine system and emphasizes the important role that human factors plays in that system.

OUTLINE

I. Story Line

   A. Introduction to main characters, I. M. Eager, B. Smart.

II. Human Factors Engineering

   A. Definition of
   B. Historical perspective

III. Systems

   A. Man-machine systems
   B. Components of man-machine system

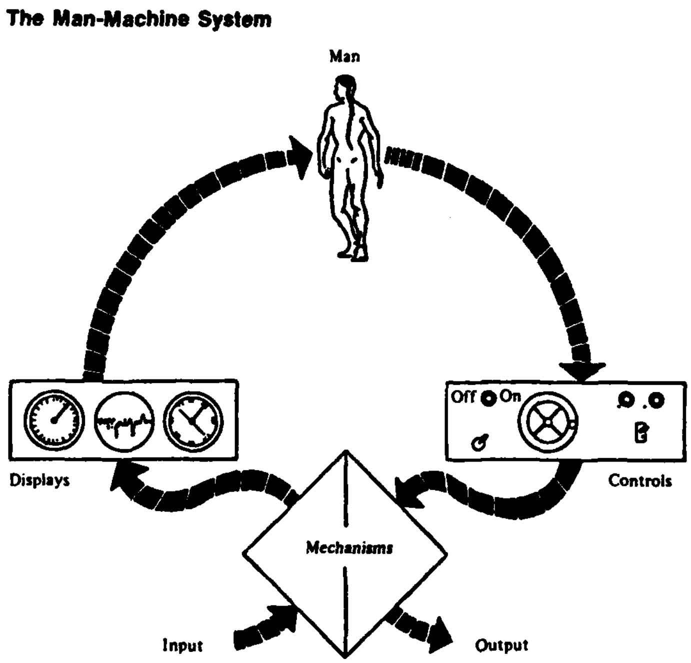


Figure 2.1. Schematic representation of a man-machine system as depicted by Taylor, 1957.

As you can see by this figure, information enters the system through its machinery and is presented to the human by machine displays. The human interprets the information and acts on it by using machine controls which in turn affect the required output.

LESSON 3: TRAGIC MISTAKES AND POSITIVE CONSEQUENCES

This lesson re-emphasizes the importance of human factors engineering by presenting the results of situations in which human factors principles were not applied. In addition, some of the positive consequences of using these principles are discussed.

OUTLINE

I. Historical Perspective

    A. Examples

II. Common Errors - Reading and Interpreting Instruments

III. Common Errors - Operating Controls

IV. Current Status of Human Error

V. Man-Machine Incompatibilities

    A. Man-machine capability differences

LESSON 4: BASIC INFORMATION PROCESSING, OR IS MAN A MACHINE?

In lesson 4 the human's ability to input, process, and act upon information presented to him is compared to the ability of a machine.

OUTLINE

I. Attention

  A. Limits to
  B. Selective attention

II. Judgments

  A. Absolute
  B. Relative

III. Man-Machine System

  A. Man the processor
  B. Stimulus-response codes
  C. Information transmission
  D. Input-output processes

READING

LESSON 4

The following is a summary of G.A. Miller's classic article, "The Magic Number Seven Plus or Minus Two: Some Limits on Our Capacity for Processing Information."

This article summarized the results of a number of studies which described, in information measurement terms, the ability to make absolute judgments. Reference to the "number seven, plus or minus two" summarized the findings from a number of studies that roughly seven signals varying along a single dimension, such as frequency or intensity, could be reliably identified. The addition of more signals simply introduced errors at a rate which left the amount of information transmitted unchanged. That is, when more than about seven different signals (seven hues, seven loudnesses, etc.) were used, the potential increase in information per signal was counter-balanced by the increase in uncertainty which remained after the signal--the errors in identifying the signals. The amount of information transmitted was found to be a function of the information in the signal (the latter increases with the number of alternative signals).

For example, if signals are tones that are varied in pitch, input information is increased from 1 bit (2 signals) to about 2 bits (4 signals) information transmitted, indicating that no errors occurred. However, with further increases in number of signals up to 3.8 bits (14 signals), there is no more than perhaps a .5 bit increase in the amount of information transmitted. Information transmitted appears to approach a limit of about 2.5 bits. This apparent limit is called the channel capacity for transmitting information of this type.

The "magic" in Miller's number seven is that this channel capacity was reached with about seven signals (or 2.5 bits) in a number of studies involving a variety of sensory channels and dimensions. Some of these findings are summarized as single dimension values in Table 4.1.

How should we interpret these results? Briefly, they mean that little will be gained by using more than seven different signals in a situation in which the signals differ along one dimension only. Furthermore, where it is highly important to avoid errors the signal set should be at or below the number indicated in Table 4.1. Thus, for example, if colors (hues) are used to code electrical wires or steam pipes where errors of identification could be very costly, then Table 4.1 indicates that no more than nine hues should be used.

In response to the last statement, the reader may say emphatically that he knows that he can identify many more than nine colors without errors. No doubt this is correct, but only if one takes "colors" to mean signals which vary in brightness and/or saturation as well as hue--that is, along more than one dimension. Table 4.1 shows that when signals vary along two or more dimensions, the number of absolutely identifiable signals increases. In other words, the upper limit on information transmission depends in an important way on how the information is coded: when signals are coded (differ) along one dimension only, channel capacity is lower than when signals differ along two or more dimensions.[1]

Table 4.1. Amount of information in absolute judgments of various stimulus dimensions.

Sensory Modality and Stimulus Dimension	*No. of Levels Which Can Be Discriminated on Absolute Basis*	*No. of Bits of Information Transmitted (H)**
Vision: single dimensions	9	3.1
Pointer position on linear scale		
Short exposure	10	3.2
Long exposure	15	3.9
Visual size	7	2.8
Hue	9	3.1
Brightness	5	2.3
Vision: combination of dimensions		
Size, brightness, and hue†	17	4.1
Hue and saturation	11-15	3.5-3.9
Position of dot in a square	24	4.6
Audition: single dimensions		
Pure tones	5	2.3
Loudness	5	2.3
Audition: combination of dimensions		
Combination of six variables‡	150	7.2
Odor: single dimension	4	2.0
Odor: combination of dimensions		
Kind, intensity, and number	16	4.0
Taste		
Saltiness	4	1.9
Sweetness	3	1.7

* Since the number of levels is rounded to the nearest whole number, the number of bits does not necessarily correspond exactly.

† Size, brightness, and hue were varied concomitantly, rather than being combined in the various possible combinations.

‡ The combination of six auditory variables included frequency, intensity, rate of interruption, on-time fraction, total duration, and spatial location.

Source: Adapted from a table presented by McCormick, E. J. *Human Factors Engineering* McGraw-Hill, 1970 (3rd ed.).

[1]Adapted from Psychology of Work Behavior by F. J. Landy and D.A. Trumbo, Homewood, Ill.: The Dorsey Press, 1976.

LESSON 5: HISTORY AND RELATED TECHNOLOGY, OR HUMAN FACTORS, THIS IS YOUR LIFE

This lesson provides you with an historical perspective of human factors engineering and its relationship with other disciplines, such as psychology and industrial engineering.

OUTLINE

I. History-HFE

   A. Ancient cultures
   B. Industrial Revolution
   C. World War II
   D. Current efforts

II. Stage of HFE Development

   A. Pretechnology
   B. Aerospace
   C. Sociotechnical
   D. Cosmopolitan

III. Review

LESSON 6: ANTHROPOMETRY, OR DO I FIT?

This lesson presents the design principles which are used when dealing with anthropometric data. In addition, you are shown how to use anthropometric tables contained in military documentation.

OUTLINE

I. Introduction

    A. Definition
    B. Historical perspective

II. Design Principles

    A. Adjustability
    B. 5th - 95th percentile range

Table 6.1. Standing body dimensions.

	PERCENTILE VALUES IN CENTIMETERS					
	5th PERCENTILE			95th PERCENTILE		
	GROUND TROOPS	AVIATORS	WOMEN	GROUND TROOPS	AVIATORS	WOMEN
WEIGHT (kg)	55.5	60.4	46.4	91.6	96.0	74.5
STANDING BODY DIMENSIONS						
1 STATURE	162.8	164.2	152.4	185.6	187.7	174.1
2 EYE HEIGHT (STANDING)	151.1	152.1	140.9	173.3	175.2	162.2
3 SHOULDER (ACROMIALE) HEIGHT	133.6	133.3	123.0	154.2	154.8	143.7
4 CHEST (NIPPLE) HEIGHT *	117.9	120.8	109.3	136.5	138.5	127.8
5 ELBOW (RADIALE) HEIGHT	101.0	104.8	94.9	117.8	120.0	110.7
6 FINGERTIP (DACTYLION) HEIGHT		61.5			73.2	
7 WAIST HEIGHT	96.6	97.6	93.1	115.2	115.1	110.3
8 CROTCH HEIGHT	76.3	74.7	68.1	91.8	92.0	83.9
9 GLUTEAL FURROW HEIGHT	73.3	74.6	66.4	87.7	88.1	81.0
10 KNEECAP HEIGHT	47.5	46.8	43.8	58.6	57.8	52.5
11 CALF HEIGHT	31.1	30.9	29.0	40.6	39.3	36.6
12 FUNCTIONAL REACH	72.6	73.1	64.0	90.9	87.0	80.4
13 FUNCTIONAL REACH, EXTENDED	84.2	82.3	73.5	101.2	97.3	92.7
	PERCENTILE VALUES IN INCHES					
WEIGHT (lb)	122.4	133.1	102.3	201.9	211.6	164.3
STANDING BODY DIMENSIONS						
1 STATURE	64.1	64.6	60.0	73.1	73.9	68.5
2 EYE HEIGHT (STANDING)	59.5	59.9	55.5	68.2	69.0	63.9
3 SHOULDER (ACROMIALE) HEIGHT	52.6	52.5	48.4	60.7	60.9	56.6
4 CHEST (NIPPLE) HEIGHT *	46.4	47.5	43.0	53.7	54.5	50.3
5 ELBOW (RADIALE) HEIGHT	39.8	41.3	37.4	46.4	47.2	43.6
6 FINGERTIP (DACTYLION) HEIGHT		24.2			28.8	
7 WAIST HEIGHT	38.0	38.4	36.6	45.3	45.3	43.4
8 CROTCH HEIGHT	30.0	29.4	26.8	36.1	36.2	33.0
9 GLUTEAL FURROW HEIGHT	28.8	29.4	26.2	34.5	34.7	31.9
10 KNEECAP HEIGHT	18.7	18.4	17.2	23.1	22.8	20.7
11 CALF HEIGHT	12.2	12.2	11.4	16.0	15.5	14.4
12 FUNCTIONAL REACH	28.6	28.8	25.2	35.8	34.3	31.7
13 FUNCTIONAL REACH, EXTENDED	33.2	32.4	28.9	39.8	38.3	36.5

*BUSTPOINT HEIGHT FOR WOMEN

Note: This table presents 13 standing body dimensions in both metric and nonmetric format for U. S. ground troops, aviators, and women.

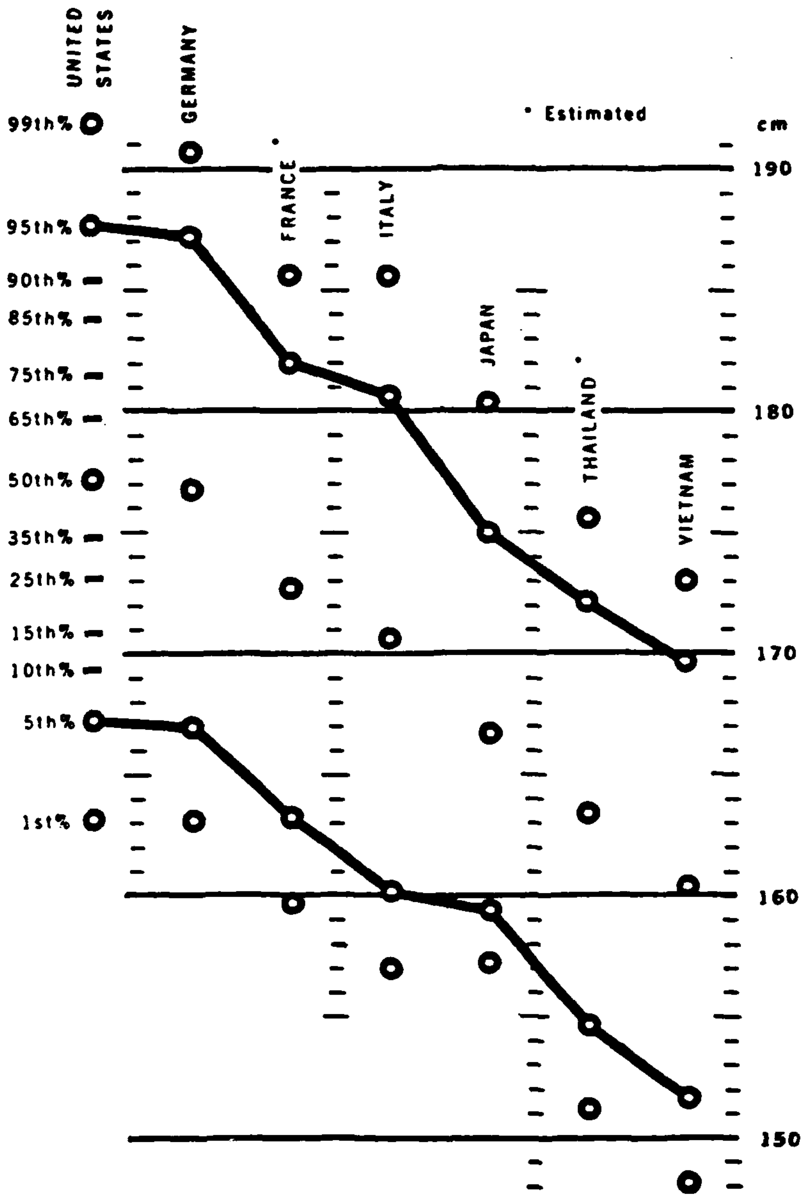


Figure 6.1. Statures of seven military populations (From Kennedy, 1975). In this figure the statures of seven military populations are compared. As can be seen, the United States population is shown to be tallest (95th percentile over 190 cm) where the Vietnamese population is shown to have the shortest stature (95th percentile at 173 cm).

LESSON 7: WORK SPACE DESIGN AND ARRANGEMENT, OR DON'T CRAMP MY STYLE

Lesson 7 deals with key aspects of layout design. General design principles to use in evaluating work spaces as well as methods for analyzing the design process are presented. In addition, a brief discussion of design priorities is given.

OUTLINE

I. Work Space Envelope

   A. General design principles

II. Analytic Methods

   A. Indexing/rating method
   B. Link analysis
   C. Prototypes

III. Component Location and Spacing Principles

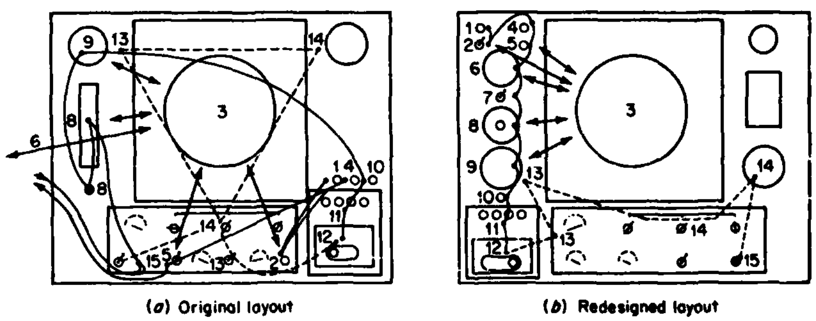


Figure 7.1. Prototype panel layout (a) and a redesigned layout (b). From Applied Ergonomics Handbook. The sequence of operations in the original prototype panel layout (a) can be seen to be ineffective. Because of the link analysis pathways, the redesigned layout is shown to be much more efficient and, therefore, more effective.

LESSON 8: VISION CAPABILITIES, OR A SHOT IN THE DARK

Lesson 8 presents an overview of how the visual sense impacts on the design of systems.

OUTLINE

I. Visual Anatomy-Supplement

II. Visibility

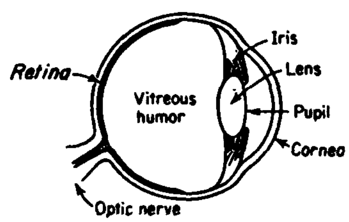
III. Panel Lighting

  A. Flood lighting
  B. Integral lighting

IV. Visual Detection, Identification, and Estimation

THE HUMAN EYE

The main parts of the human eye are shown in Figure 8.1. Light enters the eye through the transparent cornea, the amount of light being regulated by the pupil; the lens then focuses the light on the sensitive surface, the retina. Constriction and dilation of the pupil are under control of the autonomic nervous system: The parasympathetic division controls the change in pupil size as a function of changes in illumination (in much the same way as we increase the shutter opening of a camera to admit more light on a dark day and decrease the opening under conditions of bright illumination). The sympathetic division acts to dilate the pupil under conditions of strong emotion, either pleasant or unpleasant. Even under conditions of mild emotional arousal or interest, systematic changes in pupil size can be detected by means of sensitive photographic equipment.



Light passes through the pupil, is refracted by the lens, and is then brought to a focus on the retina. The retina receives the light stimulus and transmits an impulse to the brain through the optic nerve.

Figure 8.1. A cross section of the human eye

The retina, the light-sensitive surface at the back of the eye, is composed of three main layers: (1) the rods and cones, the photosensitive cells that convert light energy into nerve impulses; (2) the bipolar cells, which make synaptic connections with the rods and cones; and (3) the ganglion cells, the fibers of which form the optic nerve. Strangely enough, the rods and cones form the bottom layer of the retina. The eye is a very imperfect optical system. The light waves not only have to pass through the lens and liquids that fill the eyeball, none of which is a perfect transmitter of light, but they have to penetrate the network of blood vessels and the bipolar and ganglion cells that lie on the inside of the eye before reaching the photoreceptors where light is converted into nervous impulses. Even when the light finally reaches the rods and cones it has to strike them at an angle because the photosensitive area of these cells is pointed toward the back of the eye rather than the front. From the standpoint of efficient optics it is surprising that we can see as well as we do.

If you stare at a homogeneous background, such as a blue sky, it is possible to see the movement of blood through the retinal blood vessels that lie in front of the rods and cones. The blood vessel walls can be seen as pairs of narrow lines in the periphery of our vision, and the disk-shaped objects that appear to move between these lines are the tiny platelets of the blood as it flows through the vessel.

The most sensitive portion of the eye in normal daylight vision is a small part of the retina called the fovea. Not far from the fovea is an insensitive area, called the blind spot, where the nerve fibers from the ganglion cells of the retina come together to form the optic nerve.

The optic nerve fibers lead from each eye to the cortical areas where vision is represented (the occipital lobes). Some of the fibers go to the occipital lobe of the corresponding cerebral hemisphere (that is, from the right eye to the right cerebral hemisphere and from the left eye to the left hemisphere), whereas other fibers cross over at a junction called the optic chiasma and go to the opposite hemisphere. Fibers from the right sides of both eyes go to the right hemisphere of the cerebral cortex, and fibers from the left sides of both eyes go to the left hemisphere. Consequently, damage to the occipital lobe of one hemisphere (say, the left) will result in blind areas in both eyes (the left sides of both eyes). This fact is sometimes helpful in pinpointing the location of a cerebral tumor or injury.

Table 8.1. Recommendations for work place illumination

Condition of use	Recommendations		
	Lighting technique	Luminance of markings (ft.-l)	Brightness adjustment
Indicator reading, dark adaptation necessary.	Red flood, integral or both, with operator choice.	0.02–0.1	Continuous throughout range.
Indicator reading, dark adaptation not necessary but desirable.	Red or low-color-temperature white flood, integral, or both, with operator choice.	0.02–1.0	Continuous throughout range.
Indicator reading, dark adaptation not necessary.	White flood	1–20	Fixed or continuous.
Reading of legends on control consoles, dark adaptation necessary.	Red integral lighting red flood, or both, with operator choice.	0.02–0.1	Continuous throughout range.
Reading of legends on control consoles, dark adaptation not necessary.	White flood	1–20	Fixed or continuous.
Possible exposure to bright flashes.	White flood	10–20	Fixed.
Very high altitude, daylight restricted by cockpit design.	White flood	10–20	Fixed.
Chart reading, dark adaptation necessary.	Red or white flood with operator choice.	0.1–1.0 (on white portions of chart).	Continuous throughout range.
Chart reading, dark adaptation not necessary.	White flood	5–20	Fixed or continuous.

Note: Adapted from Van Cott and Kinkade.

DESIGN RECOMMENDATIONS

1. Binocular devices are better than monocular ones, especially for night use. The advantage of binocular devices is small in daylight when brightness levels are high.

2. For binoculars in aircraft or moving ground vehicles, use hand-held or mounted binoculars of 3 to 4 power. Powers higher than this are not recommended because of the vehicle's motion and the small field of view.

3. For daytime use on a steady platform (the ground or a ship in normal seas), magnifications up to 6 power are recommended for hand-held binoculars, and magnifications up to 20 power for mounted binoculars.

4. For night use on a steady platform, magnifications up to 10 power are recommended for hand-held binoculars, and magnifications up to 20 power for mounted binoculars.

5. An exit-pupil size of 6 mm gives the best performance--other things being equal.

6. The lines, or reticles, should be thin enough not to cut out targets but thick enough to see easily. In any event, their size should not exceed 2 min. visual angle.

7. In devices that will be used at night, reticles should be illuminated with deep-red light (above 600 mμ) and should have an adjustable intensity control.

8. Rubber eye guards should be put around the eyepiece to help the observer rest his eye at the right place and block out ambient illumination.

9. Binocular devices should provide for interpupillary distance adjustment between 2.2 and 3 in.[1]

[1]Adapted from H. P. Van Cott and R. G. Kinkade, <u>Human Engineering Guide to Equipment Design</u>, 1972, pp. 60-61.

LESSON 9: VISION DISPLAYS, OR ARE MY EYES DECEIVING ME?

The focus of this lesson is on the types and uses of various visual displays. The use of visual capabilities and limitations is examined as they relate to design concepts.

OUTLINE

I. Types of Displays

- A. Quantitative
- B. Qualitative
- C. Static
- D. Dynamic

II. Scales

- A. Digital
- B. Fixed pointer
- C. Moving pointer

III. Signal and Warning Lights

- A. Detection factors

IV. Alphanumeric and Symbolic Characters

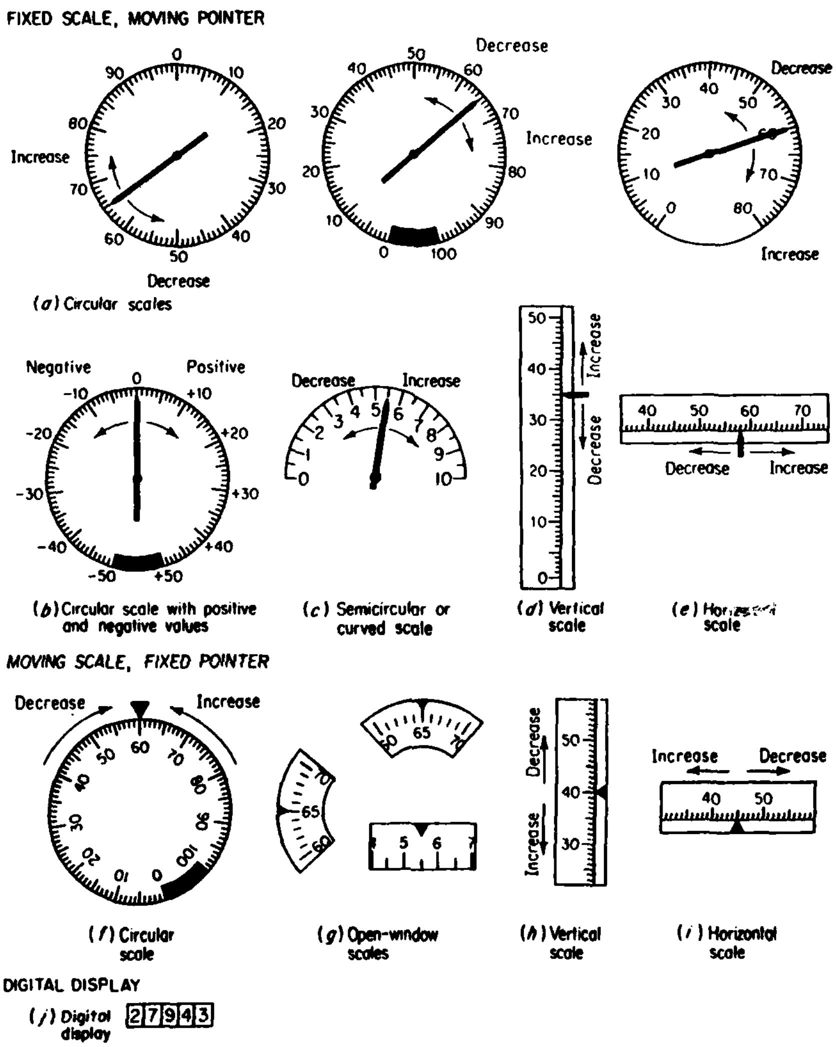


Figure 9.1. Examples of certain types of displays used in presenting quantitative information. (From McCormick, 1976).

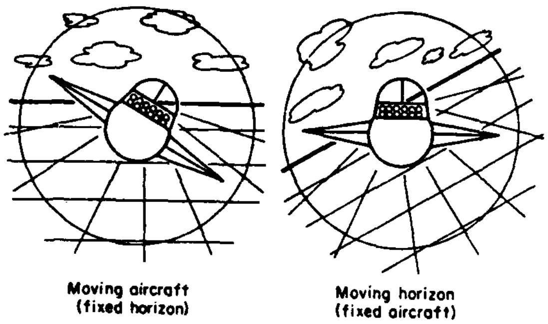


Figure 9.2. Illustration of the two basic movement relationships depicting aircraft attitude; namely, the moving aircraft (outside-in) and the moving horizon (inside-out). (Adapted from Johnson and Roscoe, 1972).

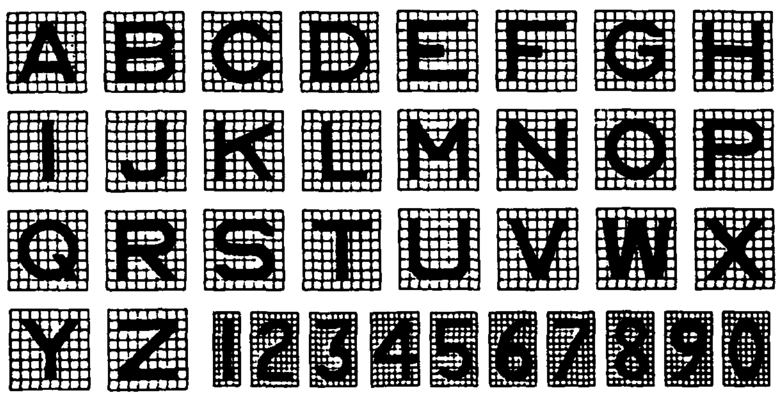


Figure 9.3. Letter and numeral font of United States Military Specification No. MIL-M-18012B (July 20, 1964).

Table 9.1. Table of letter and numeral heights for panel markings for various distances and conditions.

Viewing distance, in	0.0022D value	Nonimportant markings, $K_2 = .0$			Important markings, $K_2 = .075$		
		$K_1 = .06$	$K_1 = .16$	$K_1 = .26$	$K_1 = .06$	$K_1 = .16$	$K_1 = .26$
14	0.0308	0.09	0.19	0.29	0.17	0.27	0.37
28	0.0616	0.12	0.22	0.32	0.20	0.30	0.40
42	0.0926	0.15	0.25	0.35	0.23	0.33	0.43
56	0.1232	0.18	0.28	0.38	0.25	0.35	0.45

*Applicability of K_1 values:

$K_1 = .06$ (above 1.0 fc. favorable reading conditions)
$K_1 = .16$ (above 1.0 fc. unfavorable reading conditions)
$K_1 = .16$ (below 1.0 fc. favorable reading conditions)
$K_1 = .26$ (below 1.0 fc. unfavorable reading conditions)

Note: This table was derived from the formula H (in.) = 0.0022D $+K_1* + K_2$. (From McCormick, 1976, based on formula of Peters and Adams, 1959.

LESSON 10: AUDITORY PRESENTATIONS, OR WHEN IS AN ALARM NOT AN ALARM?

Lesson 10 is addressed to auditory presentations, such as alarms and warning devices. The principles of auditory display design and the differences between auditory and visual displays are discussed.

OUTLINE

I. General Types of Displays

   A. Displays using auditory modalities
   B. Nature of the message

II. Sound Characteristics

   A. IB, Hz
   B. Frequency, intensity
   C. Human reception capabilities

III. General Display Principles

IV. Presentation Principles

V. Warning and Alarm Systems

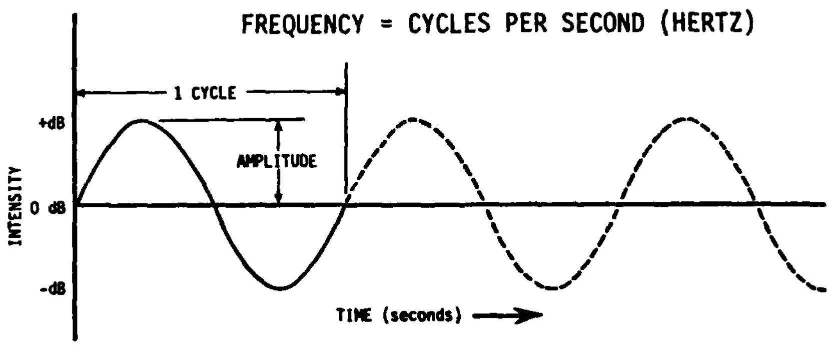


Figure 10.1. Amplitude is shown as a sine-wave pattern in this figure. The peaks of the wave are points of highest intensity, typically measured as decibel levels. The number of complete cycles per unit of time (typically 1 second) determines the frequency of the sound.

Table 10.1. Decibel levels and sound power ratios for various sounds.

Sound-power ratio	Decibels	*Environmental noises*	Specific noise sources	Decibels
100,000,000,000,000	140			140
10,000,000,000,000	130		50 hp siren (100 ft)	130
1,000,000,000,000	120		Jet takeoff (200 ft)	120
100,000,000,000	110	Casting shakeout area	Riveting machine* Cutoff saw*	110
10,000,000,000	100	Electric furnace area	Pneumatic peen hammer*	100
1,000,000,000	90	Boiler room Printing press plant	Textile weaving plant* Subway train (20 ft)	90
100,000,000	80	Tabulating room Inside sports car (50 mph)	Pneumatic drill (50 ft)	80
10,000,000	70		Freight train (100 ft) Vacuum cleaner (10 ft) Speech (1 ft)	70
1,000,000	60	Near freeway (auto traffic) Large store Accounting office		60
100,000	50	Private business office Light traffic (100 ft) *Average residence*	Large transformer (200 ft)	50
10,000	40	Minimum levels, residential areas in *Chicago at night*		40
1000	30	Studio (speech)	Soft whisper (5 ft)	30
100	20	Studio for sound pictures		20
10	10			10
1	0			0

**Operator's position*

Note: This table gives you an idea of the loudness of various decibel levels. Decibel levels above 85 are considered to be detrimental if exposure is lengthy. (From Peterson and Gross, 1972.)

Table 10.2. The characteristics and features of certain types of audio alarms

Alarm	Intensity	Frequency	Attention-getting ability	Noise-penetration ability
Diaphone (foghorn)	Very high	Very low	Good	Poor in low-frequency noise
Horn	High	Low to high	Good	Good
Whistle	High	Low to high	Good if intermittent	Good if frequency is properly chosen
Siren	High	Low to high	Very good if pitch rises and falls	Very good with rising and falling frequency
Bell	Medium	Medium to high	Good	Good in low-frequency noise
Buzzer	Low to medium	Low to medium	Good	Fair if spectrum is suited to background noise
Chimes and gong	Low to medium	Low to medium	Fair	Fair if spectrum is suited to background noise
Oscillator	Low to high	Medium to high	Good if intermittent	Good if frequency is properly chosen

Source: Deatherage [6, Table 4-2].

Note: This table, listing the characteristics and features of certain types of audio alarms, can be used to help select the appropriate alarm device to use when certain attention-getting and noise-penetration abilities are desired. (From McCormick)

LESSON 11: STANDARDIZATION OF CONTROLS, OR WHICH WAY IS UP?

This lesson discusses various types of controls and the functions best served by each type. Standardization of controls and other design features are recommended.

<u>OUTLINE</u>

I. Standard Arrangement - Population Stereotypes

II. Categorizing Controls

   A. Quantitative, qualitative, representational, continuous

III. Functions of Controls

   A. Continuous adjustment settings
   B. Discrete settings

IV. Types of Controls

   A. General types - linear, rotary
   B. Specific - push button, toggle switch, knobs, etc.

V. General rules for selection

   A. 1. MIL-STD-1472 and MIL-HDBK-759

Table 11.1. Comparison of the characteristics of common controls

Characteristic	Hand push button	Foot push button	Toggle switch	Rotary switch	Knob	Crank	Lever	Hand-wheel	Pedal
Space required	Small	Large	Small	Medium	Small-medium	Medium-large	Medium-large	Large	Large
Effectiveness of coding	Fair-good	Poor	Fair	Good	Good	Fair	Good	Fair	Poor
Ease of visual identification of control position	Poor*	Poor	Fair-good	Fair-good	Fair-good†	Poor‡	Fair-good	Poor-fair	Poor
Ease of non-visual identification of control position	Fair	Poor	Good	Fair-good	Poor-good	Poor‡	Poor-fair	Poor-fair	Poor-fair
Ease of check reading in array of like controls	Poor*	Poor	Good	Good	Good†	Poor‡	Good	Poor	Poor
Ease of operation in array of like controls	Good	Poor	Good	Poor	Poor	Poor	Good	Poor	Poor
Effectiveness in combined control	Good	Poor	Good	Fair	Good§	Poor	Good	Good	Poor

*Except when control is backlighted and light comes on when control is activated
†Applicable only when control makes less than one rotation and when round knobs have pointer attached
‡Assumes control makes more than one rotation
§Effective primarily when mounted concentrically on one axis with other knobs

LESSON 12: POSITIONING OF CONTROLS, OR THE RIGHT PLACE AT THE RIGHT TIME

Lesson 12 provides a discussion of the proper method of positioning controls. The purpose of positioning controls is explained in terms of improved performance and error reduction.

OUTLINE

I. Accidental Activation of Controls

   A. Prevention methods

II. Location of Controls and Displays

   A. Priority, grouping, association factors
   B. Location and body position
   C. Spacing between controls

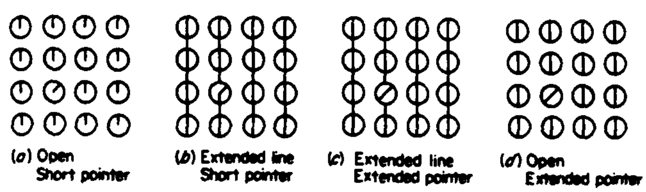


Figure 12.1. Patterns of panels of check-reading dials (Oatman, 1964).

In this study (Oatman, 1964) the extended-pointer designs (12-1 c and d) resulted in fewer errors than the other designs.

COLD	Cold temperatures lead to stiffness in the operator's hands which reduces his dexterity. Wearing of gloves or mittens causes the operator difficulty in manipulating small devices and requires more space between controls.
ALTITUDE	Heavy, cumbersome, and restrictive pressure garments must be worn, reducing both mobility and dexterity of the operator.
VIBRATION	Vibration and oscillation reduce manual dexterity and introduce an unsteadiness in the operation of controls that require smooth, continuous movement.
ACCELERATION	Acceleration and g-forces may prevent the operator from applying his full force capabilities. His limits of reach may be severely limited also.
HEAT	Heat generally introduces sweating, which may limit amount of force which the operator can apply as well as hamper his finger dexterity.
ILLUMINATION	If the operator cannot see because of poor illumination, he may be subject to error and loss of time.
RESTRAINTS	Restraint imposed on movement by restrictive garments and shoulder harnesses or seat belts may make it difficult to reach and operate controls effectively.
OPERATOR POSITION	The mobility of the operator (in terms of whether he is standing or sitting) affects both the choice and location of controls.
WEIGHTLESSNESS	In the weightless environment, the operator loses his ability to maintain his body position, and the forces he applies may upset him.
SAFETY, GENERAL	Dislodging a control accidentally may cause injury to the operator or to other personnel nearby. Possibility of falling against or bumping a control as the operator "passes by" should be considered in both the design and location of controls.

Figure 12.2. Environmental considerations in control design. This summary provides an overview of a variety of environmental factors and their effect upon performance.

LESSON 13: CONTROL DYNAMICS, OR HOW HARD TO TWIST THE KNOB

In this lesson on control dynamics you will learn about trade-offs in terms of size and distance. In addition, factors such as control-display ratio, S-R compatibility, and feedback are discussed.

OUTLINE

I. Design Concepts

   A. S-R compatibility
   B. Control-display ratio, a type of compatibility

II. Types of resistance

   A. Static friction
   B. Sliding friction
   C. Elastic resistance
   D. Viscous damping

III. Feedback

   A. Intrinsic
   B. Extrinsic

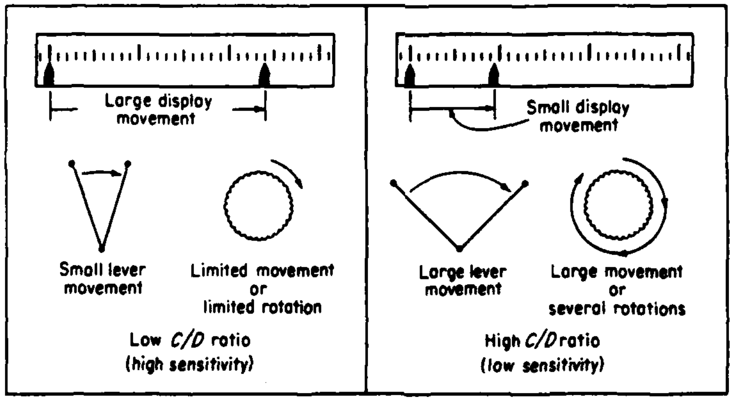
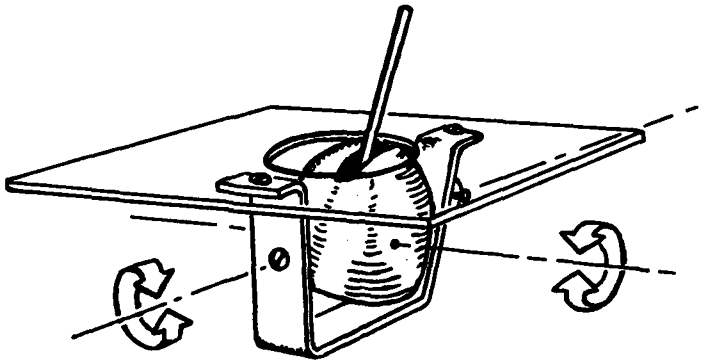
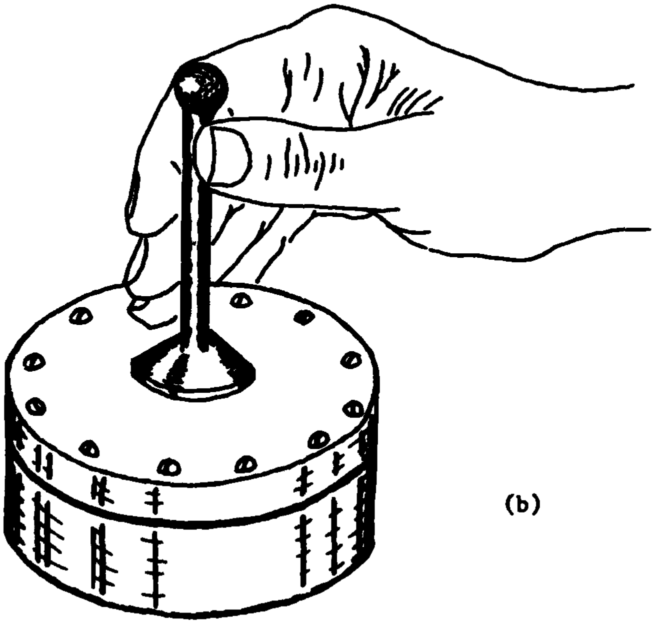


Figure 13.1. Generalized illustrations of low and high control-display ratios (C/D ratios) for lever and rotary controls. The C/D ratio is a function of the linkage between the control and display. (From McCormick, 1976).



(a)



(b)

Figure 13.2. Illustration of a two-axis isotonic (i.e., free-positioning or displacement) joy stick control (a), and an isometric (i.e., force or pressure "stiff-stick") joy stick control (b). (Adapted brom McCormick, 1976).

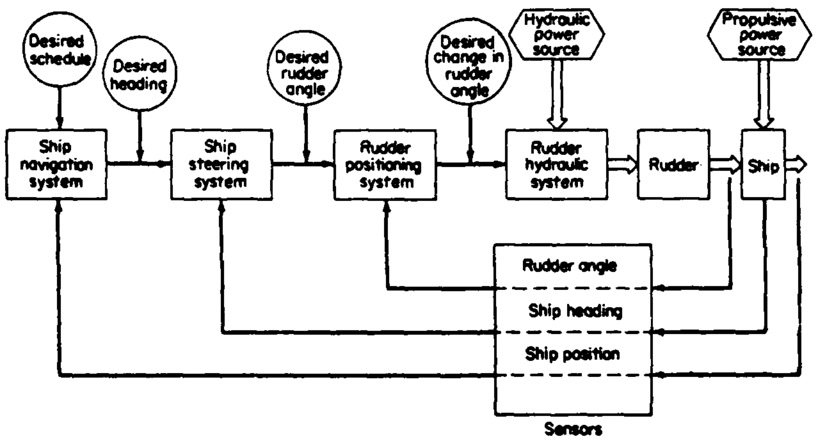


Figure 13.3. Hierarchy of tasks in steering a ship. Note that the desired goal at any given loop (e.g., the desired schedule) specifies the desired goal for the next-lower loop (e.g., desired heading), etc. Also, note the influence of any given loop (e.g., rudder hydraulic system) on the next-higher loop (e.g., rudder). (From Kelley, 1968).

LESSON 14: OTHER SENSES, OR CONTROLS THAT HAVE SHAPED-UP

Lesson 14 addresses the use of bodily senses, such as touch, pressure, pain, and smell and their use in coding design of controls.

OUTLINE

I. Review lessons 11-13

II. Touch

   A. Pressure sensitivity
   B. Pain
   C. Temperature

III. Touch Coding

   A. Shape coding
   B. Class 'A' and 'B' design
   C. Texture coding

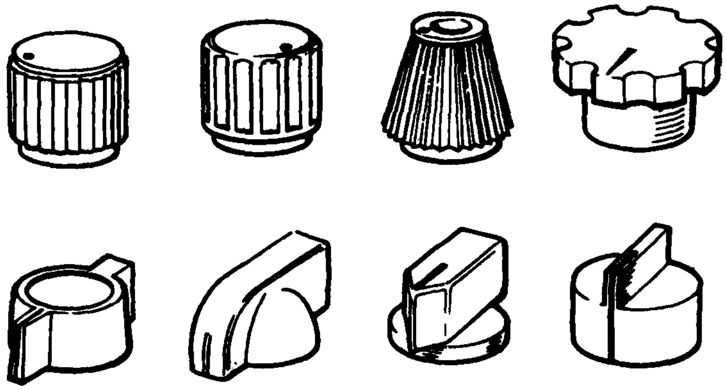


Figure 14.1. Some common control shapes. (From Woodson and Conover, 1966.)

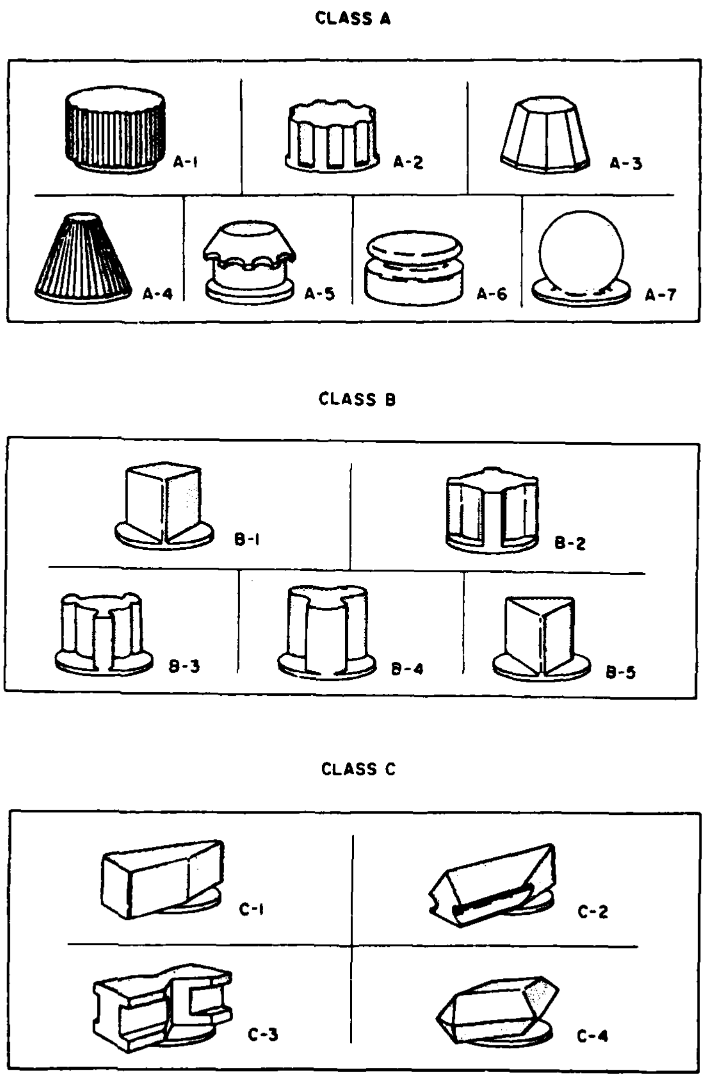


Figure 14.2. Examples of three classes of knobs: (A) those for twirling or spinning' (B) those to be used where less than a full turn is required and position is not so important; and (C) those where less than a full turn is required and position is important (From Van Cott and Kincade, 1972).

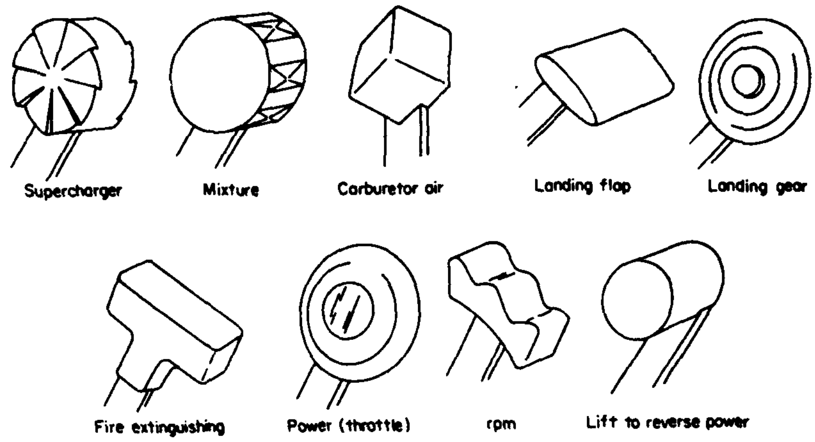


Figure 14.3. Standardized shape-coding knobs for United States Air Force aircraft. (Personnel Subsystems, 1969.)

Some of these shape-coded knobs have an additional associational value in that they are the symbolic representations of the function they control (I.g., wheel representing the landing gear).

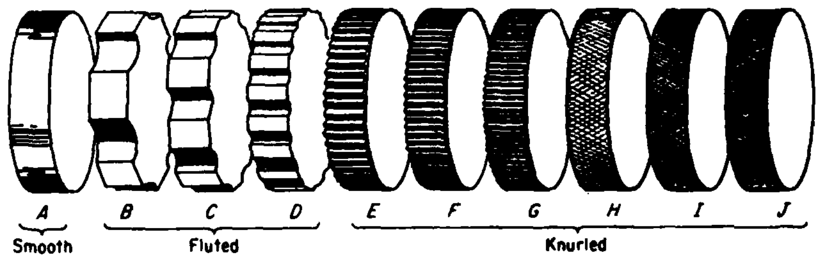


Figure 14.4. Knob designs using surface texture discrimination. Each knob represents a different textural pattern: smooth: A; fluted: B (6 troughs), C (9), D (18); and knurled: E (full rectangular), F (half rectangular), G (quarter rectangular), H (full diamond), I (half diamond), and J (quarter diamond). (From Bradley, 1967.)

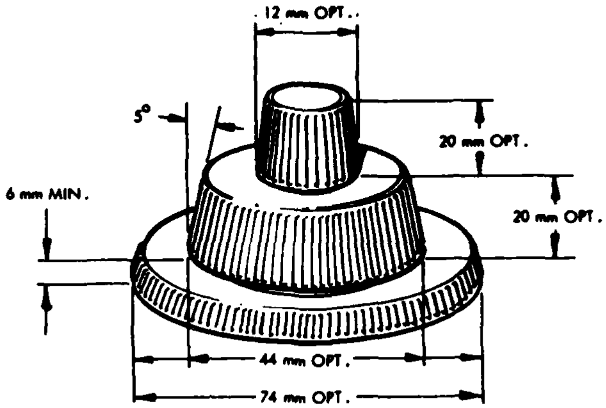


Figure 14.5A. Dimensions of concentric knobs. (From Woodson and Conover, 1966.)

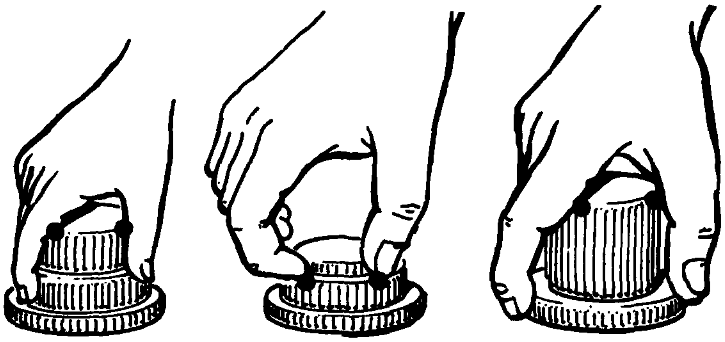


Figure 14.5B. Accidental contact points(As shown by ●) on badly designed controls. (From Woodson and Conover, 1966.)

LESSON 15: VIBRATION AND ACCELERATION, OR TAKE IT EASY, I HAVE A WEAK STOMACH!

Our modern technology has increased the speed at which man can travel. Often this increase also has produced factors such as vibration, acceleration, as well as other factors. Lesson 15 deals with these topics and how human performance is affected.

OUTLINE

I. Vibration

  A. Definitions
  B. Measurement
  C. Body parts affected

II. Whole Body Vibration

  A. Performance effects
  B. Tolerable limits

III. Acceleration

  A. Performance effects
  B. Protective measures

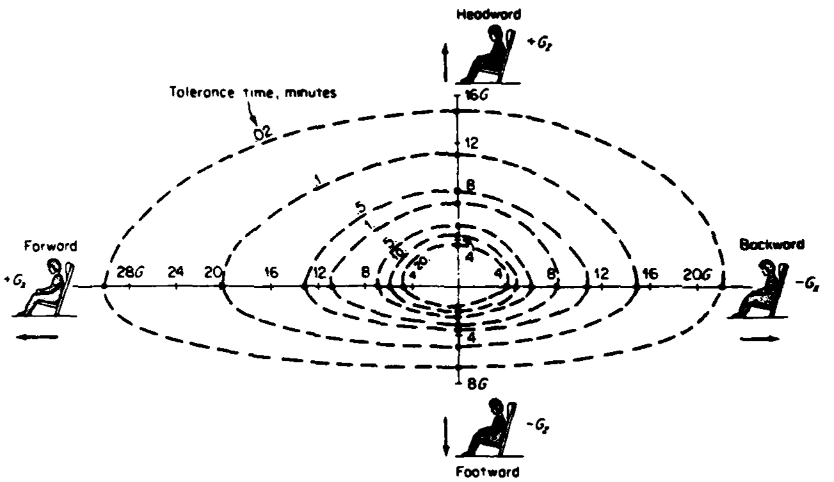


Figure 15.1. Average levels of linear acceleration, in different directions, that can be tolerated on a voluntary basis for specified periods of time. (Adapted from Chambers, 1963 by McCormick, 1975

In each curve, the average G which can be tolerated for a given time is shown.

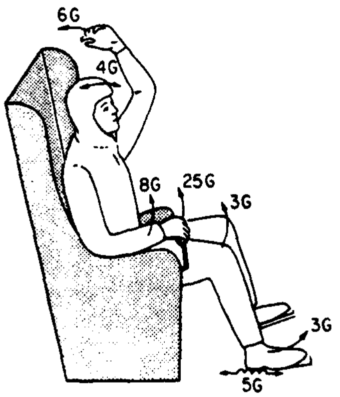


Figure 15.2. The G forces near the threshold of various body movements. (Adapted from Chambers and Brown, 1959 by McCormick, 1975.

At a given position, various body movements are barely possible under the G forces indicated.

LESSON 16: VIGILANCE, OR STAY AWAKE IF YOU CAN

In lesson 16 you will learn about performance capabilities and limitations when vigilance or continuous watch-keeping tasks are required. This lesson also presents a look at various work/rest schedules and their effect upon the human.

OUTLINE

I. Vigilance

- A. Definition
- B. Examples

II. Performance decrements due to vigilance

- A. Time frame
- B. Magnitude of decrement
- C. Display characteristics

III. Signal Characteristics

- A. Noise
- B. Signal intensity
- C. Rate of signal presentation

IV. Other factors affecting watch-keeping behavior

- A. Environmental conditions, noise
- B. Atmospheric temperature
- C. Procedural conditions, work/rest schedules

LESSON 17: TEMPERATURE EFFECTS, OR BABY, IT'S COLD OUTSIDE

In lesson 17 you will learn how you, as a human factors specialist, must deal with environmental temperatures in designing equipment. Extremes in terperature also are discussed as to their effects on performance.

OUTLINE

I. Reactions to Temperature Change

A. Physiological
B. Adaptation, Sensitization and habituation
C. Effective temperature

II. Extreme Cold

A. Physiological and performance effects

Table 17.1. Cooling effects of temperature and wind speed

Wind speed		Air temperature, °F						Air temperature, °C					
mi/h	km/h	40	20	10	0	-10	-30	4	-7	-12	-18	-23	-29
calm		40	20	10	0	-10	-20	4	-7	-12	-18	-23	-29
5	9	37	16	6	-5	-15	-26	3	-9	-14	-20	-26	-32
10	16	28	4	-9	-21	-33	-46	-2	-16	-23	-29	-36	-43
20	32	18	-10	-25	-39	-53	-67	-8	-23	-33	-37	-47	-55
30	49	13	-18	-33	-48	-63	-79	-11	-28	-36	-43	-52	-62
40	64	10	-21	-37	-53	-69	-85	-12	-29	-38	-47	-56	-65

Note: This table was adapted from Siple and Passel by McCormick, 1976.

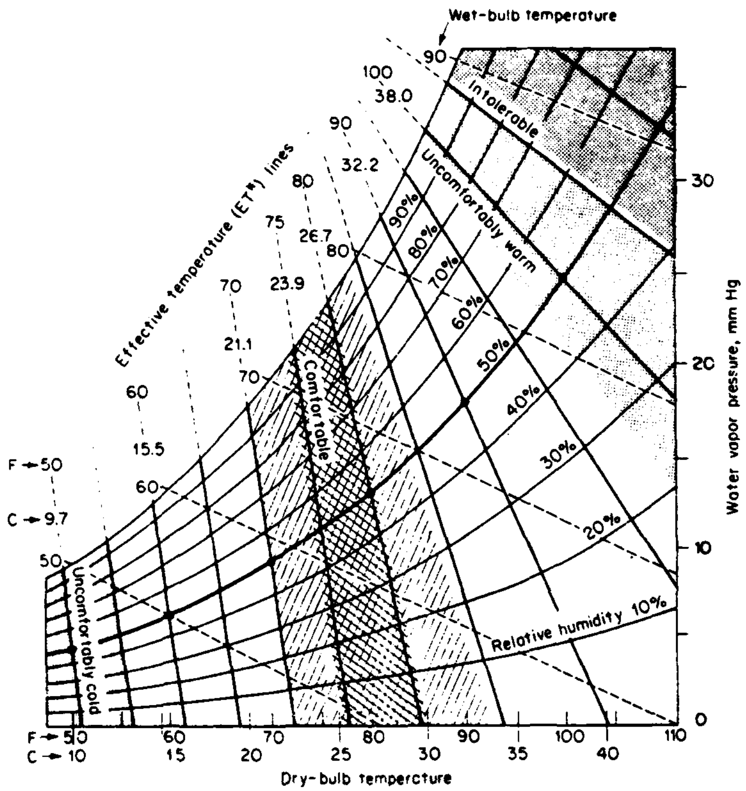


Figure 17.1. Effective temperature (ET scale). (Adapted from ASHPAE handbook of fundamentals).

Each line represents a combination of dry bulb temperature and relative humidity. As also can be seen, this figure shows areas of various thermal sensations, such as comfortable, intolerable, etc.

LESSON 18: ATMOSPHERIC EFFECTS, OR I CAN'T BREATHE

In this lesson various atmospheric gases (CO, CO_2, etc.) are di~~s~~cuseed in terms of their effects upon human beings; both physiological and performance effects are presented. In addition, radiation effects are discussed and the involvement of the human factors specialist in preventative measures is focused on.

OUTLINE

I. Description of Atmosphere

   A. Gases, density, pressure

II. Hypoxia

   A. Factors causing
   B. Effects, physiological and performance

III. CO_2 and CO

   A. Physiological and performance effects
   B. Military specifications

IV. Radiation

   A. Measurement definitions
   B. Effects of overexposure

V. Prevention

   A. Mask
   B. Clothing
   C. Collective protection methods

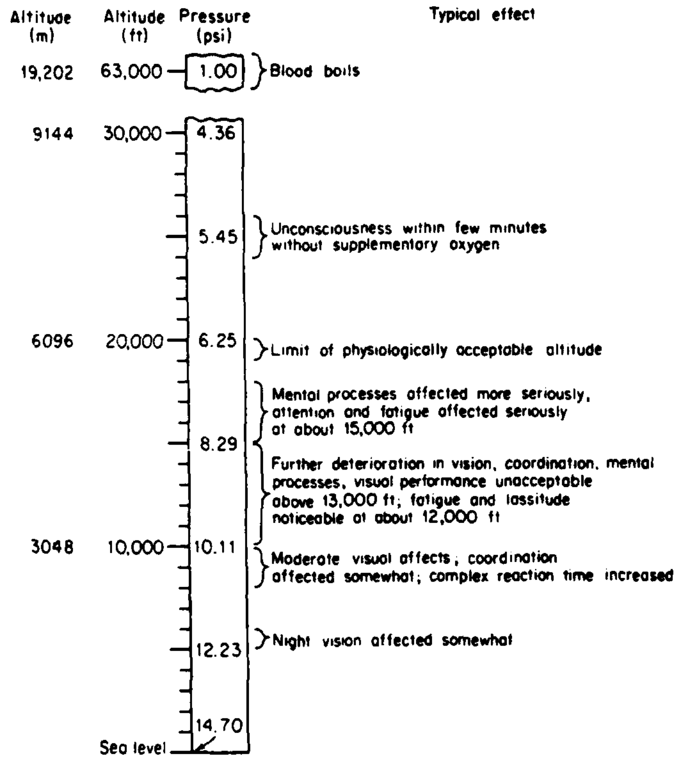


Figure 18.1. Effects of pressure and altitude changes on the human. (From McCormick, 1976).

As can be seen in this figure, as altitude increases and pressure decreases, there is an increasing adverse physiological effect.

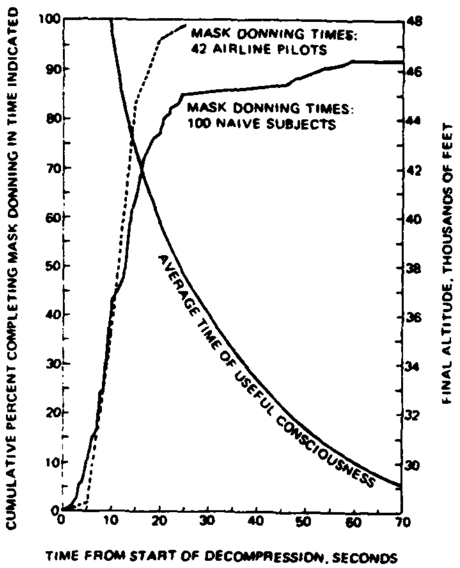


Figure 18.2. Effects of decreased oxygen on mask-donning times. (From Parker and West, 1973).

This figure allows you to see that the average time of useful consciousness has a dramatic drop-off in an hypoxia situation.

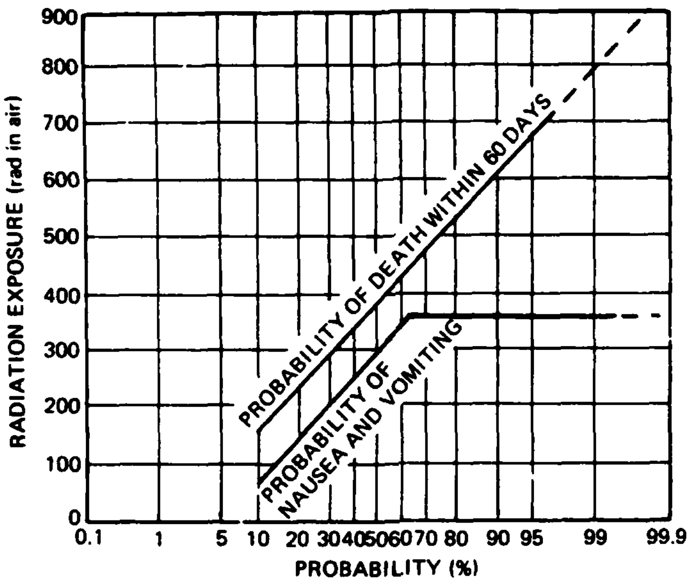


Figure 18.3. Whole body radiation dose and first symptoms of death. (Langham, 1967).

In addition to the probability of death, this figure also presents the probability of various radiation exposures causing nausea and vomiting.

LESSON 19: NOISE, OR CAN YOU HEAR ME?

Lesson 19 deals with the topic of noise and its effects, both physiological effects and effects on performance. Variables of noise which affect hearing as well as aids to protect against hearing loss or impairment are presented.

OUTLINE

I. Auditory Anatomy

  A. Structure
  B. How sound travels in the ear
  C. Mechanical and electrical transmission

II. Properties of auditory stimuli

  A. Frequency, intensity

III. Communication

  A. Maskers

IV. Physiological Effects

  A. TTS
  B. PTS
  C. Damage risk criteria

V. Protection Against Noise

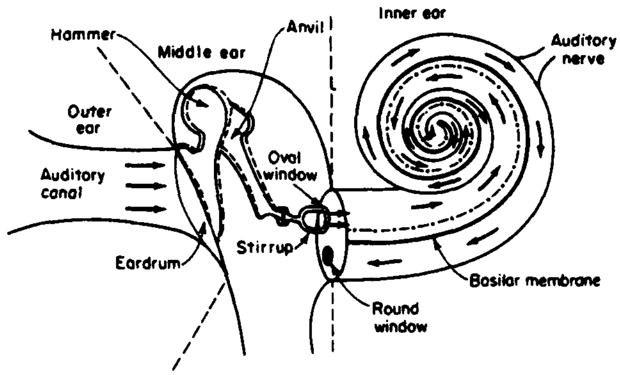


Figure 19.1. Schematic drawing of the ear. Sound waves travel to tympanic membrane, which in turn vibrates the ossicles of the middle ear. This vibration is transmitted through the membrane of the oval window to the cochlea, where the vibrations are transmitted by liquid through membranes to sensitive hair cells, which send nerve impulses to the brain. (From McCormick, 1976).

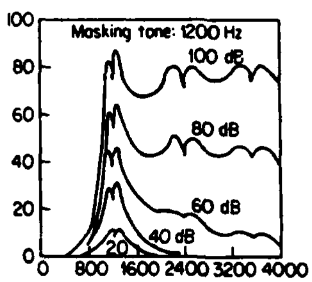


Figure 19.2. Frequency of tones being masked, hertz (Hz). Masking of pure tones by pure tone of 1200 Hz (100, 80, 60, 40, and 20 dB). (From Wegel and Lane, 1924).

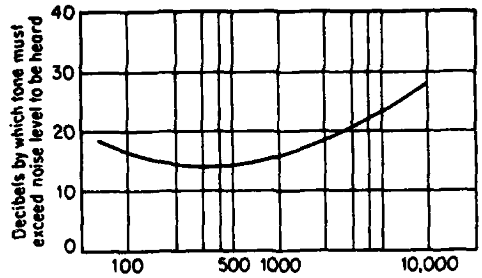


Figure 19.3. Frequency of tones being masked, hertz (Hz). Pure tones are being masked by noise. (From W. A. Munson in C.M. Harris, 1957).

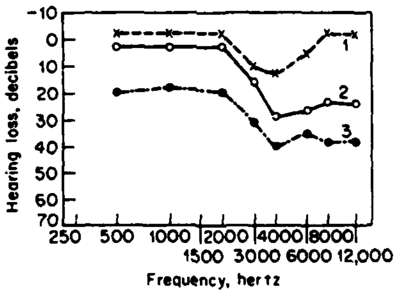


Figure 19.4. Audiograms for an individual showing three stages in the development of noise-induced permanent threshold shift (NIPTS). (From Tomlinson, 1971).

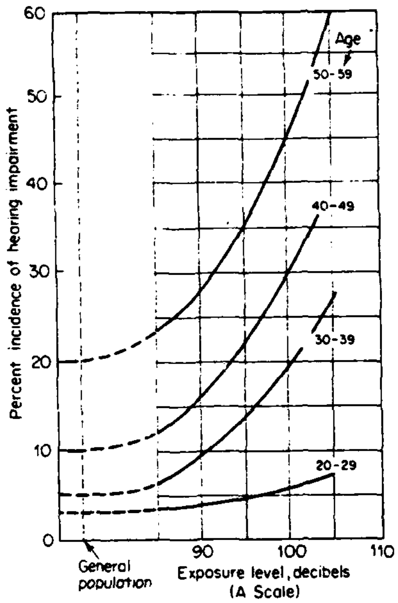


Figure 19.5. Incidence of hearing impairment in the general population and in selected populations by age group and occupational noise exposure; impairment is defined as a hearing threshold level in excess of an average of 15 dB at 500, 1,000, and 2,000 Hz. (From Industrial noise manual, 1966, p. 420).

REDUCTION OF LOUDNESS

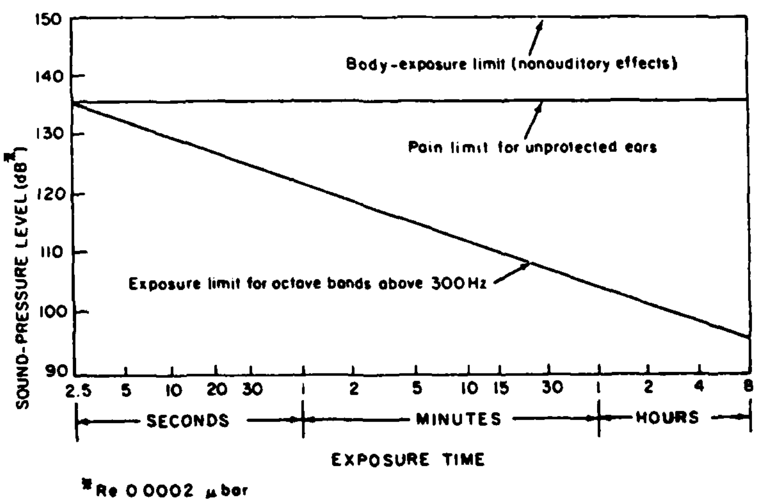


Figure 19.6. Damage risk criteria for various exposure times up to 8 hr. Pain limit for unprotected ears is shown at 135 dB. When ear protectors are used, sound pressure level in sound field can exceed these criteria by amount of attenuation provided by protectors. Body-exposure limit at 150 dB is point at which potentially dangerous non-auditory effects occur. This level should not be exceeded in any case (Eldred et al., 1955).

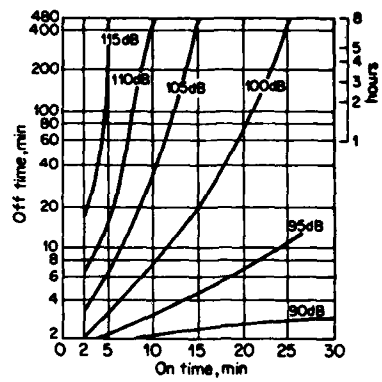


Figure 19.7. Guide to allowable exposure times for intermittent noise. Each curve is labeled with the average value for octave bands with center-line frequencies of 500, 1,000, and 2,000 HZ.) The vertical scale shows the off time which must follow noise exposure of the duration shown on the horizontal scale (on time) to avoid temporary threshold shifts greater than 12 dB at 2,000 Hz. (From American Academy of Opthalmology and Otolaryngology, 1964.)

LESSON 20: REVIEW

The first section of your human factors engineering course has dealt with topics which are all concerned with the human's capabilities and limitations. In this lesson a review of lessons 1-19 is offered.

NOTES:

LESSON 21: SYSTEM ACQUSITION

Lesson 21 begins the second section of your course in human factors engineering. How the human fits into the system is the theme of this section, and this particular lesson emphasizes the importance of human factors engineering in the military system acquisition cycle.

OUTLINE

I. Department of Defense Acquisition Policy

  A. Variation across systems
  B. OMB A-109
  C. Dod 5000.1

II. Phases of Weapons System Acquisition Process

  A. Concept exploration
  B. Demonstration and validation
  C. Full-scale development
  D. Production and deployment

III. HFE and the Acquisition Process

1. PRELIMINARY DESIGN PHASE

(a) Why is this system being sought? What mission will the system be expected to fulfill? More particularly, what is this new system expected to do that existing systems are not doing or are not doing well enough?
(b) How is the system to fulfill its mission? What are the stages of mission execution? What functions must be accomplished by the system at each stage?
(c) In what environments must the system function? What particular hazards will obtain? What stresses or demands are likely to be placed on the system?
(d) Who will benefit by system operations? Who will use the system? What kinds and numbers of operator and/or maintenance personnel are available? Are needed?
(e) What are the major technological options? What alternative configurations are feasible? What particular resource or class of resource is most crucial to prospective system effectiveness?

2. ADVANCED DESIGN PHASE

(a) What functions should be assigned to human operator and support personnel? What conditions will impose peak task loads on the operator or operators? What conditions (e.g., long periods of inactivity) will tend to degrade operator performance? What pattern of decision/action will occur at crucial mission stages?
(b) What information is required by operators (and/or support personnel) in order to fulfill their functions? What is the probable pattern of channels and flow rate for this information? In what form (i.e., code, mode, format) will the information be most useful to the operator?
(c) How many humans are needed to man and support the system under normal and peak conditions? What special skills, capabilities, or attributes are needed for effective operator performance? What special training, if any, will be required? Is such training feasible? What resources will be required to implement the training?
(d) How should the assigned functions be distributed among operator and support personnel? How should the work stations be arranged? What instrumentation is required at each work station? How should this instrumentation be laid out?
(e) What specific devices, tools, or controls are most appropriate to the pattern of task actions that will be imposed on operator and support personnel? What kinds of aids, guides, indicators, locks, interlocks, cover plates, etc., would be useful to facilitate correct actions and prevent operator errors? What means are available to allow quick recovery or to maintain the safety and integrity of the system in the event of operator error or failure?

3. MOCK-UP TO PROTOTYPE FABRICATION PHASE

(a) What options are available for eliminating, combining, or simplifying any of the instrumentation?
(b) *What will be the effect, if any, on human performance, safety, or morale of any proposed* changes in configuration or instrumentation?
(c) What safeguards, if any, are required to insure adherence to the design plan and functional requirements of the system? What quality control procedures are required to insure the validity of human factors considerations in the final product?

4. TEST AND EVALUATION PHASE

(a) By what means can test and evaluation be made as realistic as possible in terms of the ultimate operator and support personnel and in terms of operational conditions?
(b) What criteria of system and operator performance are logical in terms of the mission and functions assigned? What measurement procedures will yield data which are valid with respect to such criteria? What test instrumentation is required?
(c) What form of test design will yield unequivocal answers to questions of the effectiveness, operability, and maintainability of the system? What is the most economical way of implementing the test design required?

Figure 21.1. Sequential listing of typical questions that a human engineer might be expected to deal with in the system acquisition/development process. The human engineer must look at a system acquisition/development from every aspect that impacts on man. (Adapted from Van Cott and Kinkade, Human Engineering Guide to Equipment Design, American Institute for Research, Washington, D.C., D.C., 1972.)

LESSON 22: SYSTEMS ANALYSIS, OR THE BIG PICTURE

Lesson 22 continues the discussion about analyzing the system with the human in mind. The primary focus of this lesson is on the phases of systems analysis such as functional, decisional, flow, and job analyses.

OUTLINE

I. Purpose of System Analysis:

   A. Scheduling
   B. Identifying limiting factors
   C. System performance criteria
   D. Design options
   E. Evaluation of systems

II. Stages of System Analysis:

   A. Requirements analysis
   B. Function analysis
   C. Task analysis

III. Major Problem Areas

   A. *Subsystems' interaction*

      1. Sectionalization technique

   B. Criterion determination
   C. Defining human performance effectiveness

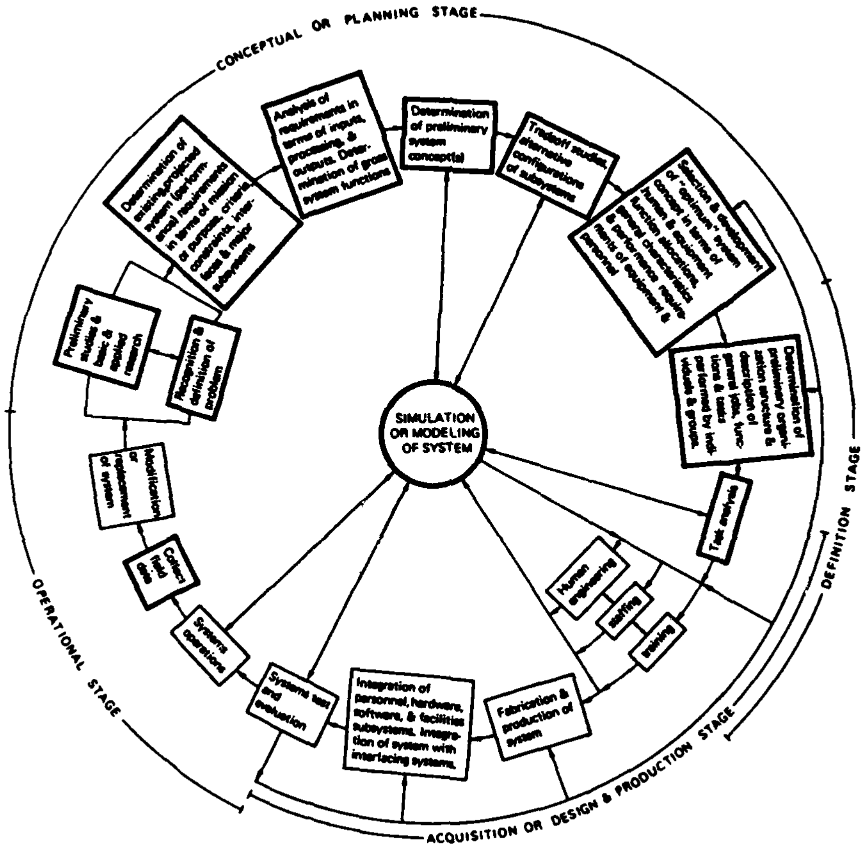


Figure 22.1. Systems development flow diagram. Rectangles and circles with heavy borders indicate systems analysis activities of greatest relevance to this lesson. Not all feedback loops are shown. Note that the simulation or model can be viewed as a constricted version of the systems development process itself (from DeGreene, 1970).

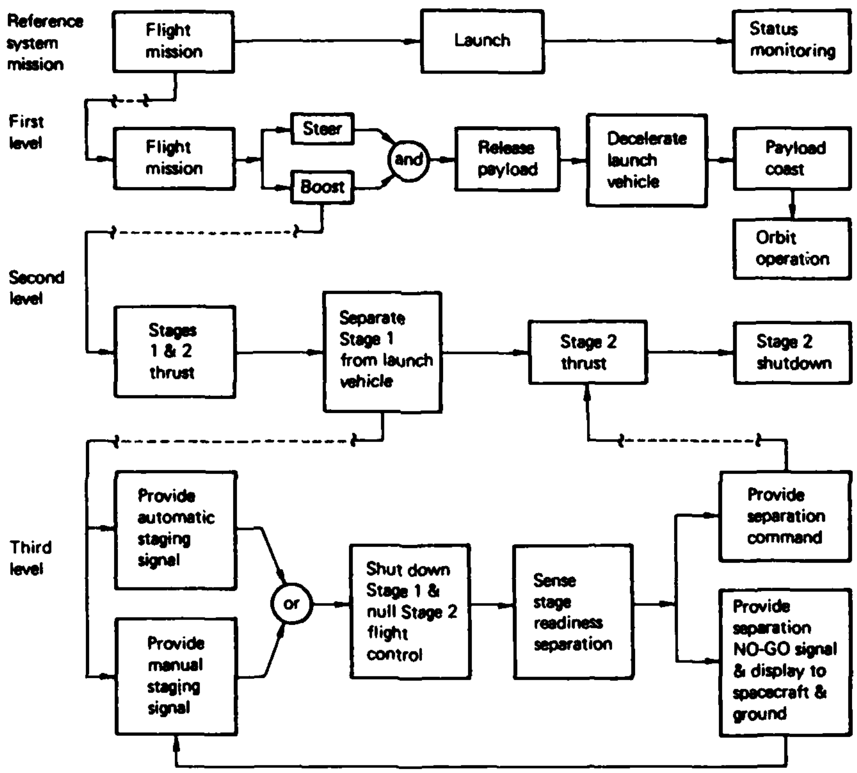


Figure 22.2. System requirements described by functional flow block diagram. (From De Greene, 1970.)

LESSON 23: TASK ANALYSIS: HISTORY AND PERSPECTIVES

In lesson 23 you will learn about significant problem areas in task analysis (TA) and how these areas are currently being dealt with. In this regard, TA will be explained as it fits into the process of the system. A major focus will be on the pertinent TA definitions.

OUTLINE

I. Recent History of Task Analysis

II. Definition of Task Analysis

III. Other Important Task Analysis Factors:

A. Systems mission and function
B. Job, task, sub-task, task element
C. Task inventory, task taxonomy

IV. Output of Task Analysis

A. Design
B. Training
C. Test and evaluation
D. Manning
E. Workload

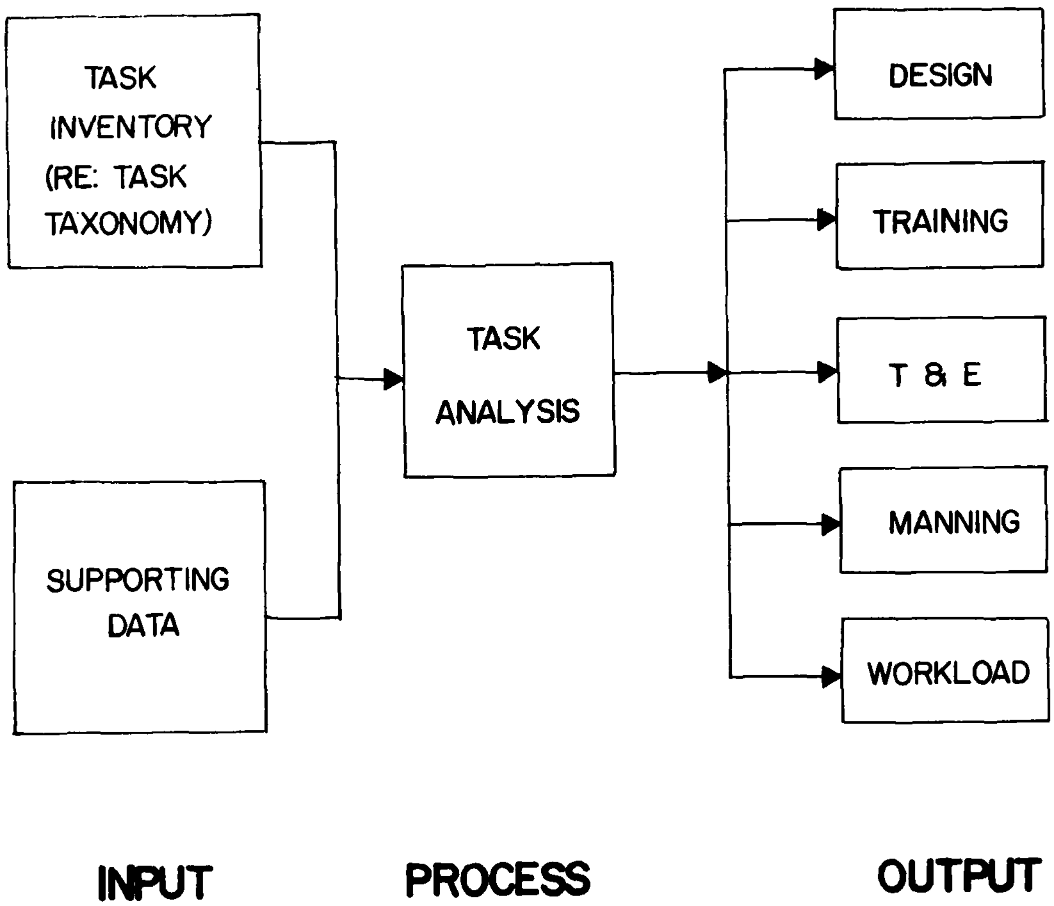


Figure 23.1. Schematic of task analysis.

Table 23.1. Taxonomy for task inventory and pertinent task analysis definitions

MISSION	What a man-machine system is supposed to accomplish
FUNCTION	Broad category of activity performed by a man-machine system
JOB	Combination of all human performance necessary for operation and maintenance of one personnel position in a system
DUTY	Set of operationally-related tasks within a given job
TASK	A composite of related activities
SUB-TASK	Activities which fulfill a portion of the purpose of a task
TASK ELEMENT	The smallest logical unit of behavior necessary to complete a task or sub-task
TASK INVENTORY	A listing of all tasks performed within a job
TASK TAXONOMY	A classification scheme for the different levels of activities in a system, i.e., job - task - sub-task, etc.
TASK-ANALYSIS	Analytic process applied to a task inventory and supporting data to produce a description of some aspect of the human component in a manned system, and to provide information for design, training, test and evaluation, manning and workload

NEW TASK ANALYSIS DIDS
DI-H-0001-DI-H-0007

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE TASK INVENTORY REPORT	DOD	DI-H-0001
3. DESCRIPTION/PURPOSE The purpose of this report is to list all tasks involved in the operation and maintenance of a system under development for which a task analysis process must be carried out.	4. APPROVAL DATE 22 January 1980 5. OFFICE OF PRIMARY RESPONSIBILITY Army 6. DDC REQUIRED 8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP This DID is primarily applicable to MIL-STD-XYZ. It is also applicable to any MIL-STD or DID which requires the performance of a task analysis.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-STD-XYZ TRADOC PAM 351-4(T) MCSL NUMBER(S)	

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE TASK ANALYSIS OF CRITICAL TASKS REPORT	DOD	DI-H-0002
3. DESCRIPTION/PURPOSE This report describes the results of task analysis by the contractor of critical tasks required to operate and maintain a system under development. The report shall provide a basis to evaluate the design of the system, equipment or facilities.	4. APPROVAL DATE 22 Jan. 1980 5. OFFICE OF PRIMARY RESPONSIBILITY Army 6. DDC REQUIRED 8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP This DID is applicable to MIL-STD-XYZ (paragraph 5.1). This DID is also applicable to a portion of the work task delineated in paragraphs 3.2.1.3.1 and 3.2.1.3.2 of MIL-H-46855.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-STD-XYZ MIL-H-46855 TRADOC PAM 351-4 (T) MCSL NUMBER(S)	

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE TASK ANALYSIS FOR DESIGN FOR OPERATOR/ MAINTAINER REPORT	DOD	DI-H-0003
3. DESCRIPTION/PURPOSE This report provides a source of data to evaluate the extent to which equipment meets human performance requirements and human engineering design criteria, when that equipment has an interface with an operator and/or a maintainer. The report shall be prepared so as to facilitate the development of human engineering design approach documents, DI-H-7056 and DI-H-7057.	4. APPROVAL DATE 22 January 1980 5. OFFICE OF PRIMARY RESPONSIBILITY Army 6. DDC REQUIRED 8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP This DID is applicable to MIL-STD-XYZ (paragraph 5.1). This DID is also applicable to work tasks delineated in MIL-H-46855 (paragraphs 3.2.1.2 through 3.2.1.4, 3.2.2 and 6.2.5). This DID is also applicable to DI-H-7056 and DI-H-7057.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-STD-XYZ MIL-H-46855 DI-H-7056 DI-H-7057 MCSL NUMBER(S)	

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE TASK ANALYSIS FOR TRAINING REPORT	DOD	DI-H-0004
3. DESCRIPTION/PURPOSE To provide timely and accurate identification of technical tasks to be performed by operator and maintenance personnel necessary for proper operation and maintenance of system/equipment in accordance with the mission employment doctrine and support concept of that system. This report is also to provide information necessary to develop training materials, training devices and training testing.	4. APPROVAL DATE 22 Jan. 1980 5. OFFICE OF PRIMARY RESPONSIBILITY Army 6. DDC REQUIRED 8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP This DID applies to MIL-STD-XYZ	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-STD-XYZ MCSL NUMBER(S)	

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE TASK ANALYSIS FOR TEST AND EVALUATION REPORT	DOD	DI-H-0005
3. DESCRIPTION/PURPOSE This DID is to provide that task analysis information required to perform human engineering testing of a system. This DID helps determine whether a trained person can perform assigned tasks in the system, the extent to which his performance is affected by equipconfiguration, and the effect of human performance on system performance.	4. APPROVAL DATE 22 Jan. 1980 5. OFFICE OF PRIMARY RESPONSIBILITY Army 6. DDC REQUIRED 8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP This DID applies to MIL-STD-XYZ. It also applies to work tasks described in paragraphs 3.2.2.4 and 3.2.3 of MIL-H-46855. It also applies to DI-H-7058.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-STD-XYZ DI-H-7058 MIL-STD-1472 MCSL NUMBER(S)	

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE TASK ANALYSIS FOR MANNING REPORT	DOD	DI-H-0006
3. DESCRIPTION/PURPOSE To provide timely and accurate information on tasks to identify manpower requirements necessary for the operation and maintenance of system/equipment in accordance with the mission, employment doctrines, qualitative and quantitative personnel requirements, and support concept.	4. APPROVAL DATE 5. OFFICE OF PRIMARY RESPONSIBILITY Army 6. DDC REQUIRED 8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP This DID applies to MIL-STD-XYZ. It also applies to logistic support analysis (LSA) data, and integrated logistics support (ILS) data file. This DID also applies to DI-H-0004.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-STD-XYZ, LSA, ILS, APM 611-101,-112,-201 APM 39-1 DI-H-0004 NAVPERS 158396 NAVPERS 18018D MCSL NUMBER(S)	

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE TASK ANALYSIS FOR WORKLOAD REPORT	DOD	DI-H-0007
3. DESCRIPTION/PURPOSE The purpose of this report is to provide a complete description of tasks required to operate or maintain a system that will facilitate the assessment of the workload of system operators or maintainers.	4. APPROVAL DATE 22 Jan. 1980 5. OFFICE OF PRIMARY RESPONSIBILITY Army 6. DDC REQUIRED	
7. APPLICATION/INTERRELATIONSHIP This DID applies to MIL-STD-XYZ.	8. APPROVAL LIMITATION 9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-STD-XYZ MCSL NUMBER(S)	

LESSON 24: TASK ANALYSIS, OR FITTING TA INTO THE SYSTEM

In this second lesson on task analysis you will learn how task analysis is performed in regard to the desired systems outputs. In addition, examples of task analysis worksheets will be presented.

OUTLINE

I. Stages in Task Analysis Process

   A. Identify task, subtask, task element
   B. Develop specific behavioral objectives
   C. Identify supporting skills and knowledge

II. Task Statements

   A. Specific behavioral objectives

III. Task Analysis Worksheet

IV. Sampling Techniques

   A. Activity sampling
   B. Process Analysis

FUNCTION (1)	OPERATE AIRCRAFT POWER PLANS AND SYSTEM CONTROLS									
TASK (2)	CONTROL JET ENGINE OPERATION									
SUBTASK (3)	ACTION STIMULUS (4)	REQUIRED ACTION (5)	FEEDBACK (6)	TASK CLASSI-FICATION (7)	POTENTIAL ERRORS (8)	TIME (9)		WORK STATION (10)	SKILL LEVEL (11)
						ALLOW-ABLE (9a)	NECES-SARY (9b)		
3.1 Adjust engine r.p.m.	4.1 Engine r.p.m. on tachometer	5.1 Depress throttle control downward	6.1 ^Increase in indicated tachometer r.p.m.	7.1 Operator task, aircraft commander	8.1 a. Misread tachometer b. Fail to adjust throttle to proper r.p.m.	9a.1 10 sec.	9b.1 7 sec.	10.1 aircraft commanders seat	11.1 Low

Figure 24.1. A format for task allocation and analysis.

TASK ANALYSIS WORKSHEET

TASK: Electrical Continuity Check of Microswitch

PERSONNEL: Electrical Mechanic

OPERATION:_______________ DATE:__________

NO.	ELEMENTS	P	J	M
1.	Unscrew three hold-down screws and remove coverplate of container.			
2.	Inspect microswitch for security and adjustment.			
3.	Adjust microswitch position and tighten two securing screws.			
4.	Place two electrodes on microswitch receptacle pins and read meter for electrical continuity.			
5.	Replace coverplate and tighten down three hold-down screws.			
	High level demand factors:			
	Item 2.--Difficult to see or feel if adjustment is correct			
	Item 3.--Difficult to decide the adequate amount of adjustment required, a design feature			

Figure 24.2. Sample task analysis worksheet.

ANALYSIS OF HUMAN PERFORMANCE TASKS

System Stoner 63 Rifle Task Corrective Maintenance (Detail Stripping) Subject Ident. ________ Date ________

STEP NO.	DESCRIPTION OF PROCEDURE	TIME	ERROR CODE	DESCRIPTION OF PART
1.	INSPECT WEAPON FOR SAFE CONDITION			
1.1	Pull cocking handle to the rear until action is fully open.			
1.2	Push up on the bolt stop to lock the action in the open position.			
1.3	Return the cocking handle to the forward position.			
1.4	Move the selector lever to the "S" position (safe).			
1.5	Depress the magazine latch toward the magazine.			
1.6	Rotate the magazine forward and remove it from the rifle.			
1.7	Look in the receiver and chamber and assure that the weapon is cleared of all ammunition and is safe to disassemble.			
1.8	Pull the cocking handle to the rear until the bolt stop is released.			
1.9	Using the cocking handle ease the bolt forward,closing the action.			
2.	FIELD STRIP			
2.1	With the bolt closed and selector lever on S (safe), push the take-down pin out toward the right side of the weapon with the point of a cartridge.			
2.2	Holding the rifle with the left hand under the receiver, muzzle pointing down, pull out the take-down pin with the right hand until the trigger housing group is allowed to pivot downward. The take-down pin cannot be removed from the trigger housing assembly.			
2.3	Still holding the open weapon in the left hand, grasp the driving spring assembly and remove.			
2.4	Place the right hand over the back of the receiver, and rotate the rifle muzzle up slowly. The carrier, piston and bolt assembly will slide out of the receiver assembly.			
2.5	Remove the trigger housing group retaining pin, ano remove the trigger housing group from the receiver group.			
2.6	Remove the magazine adapter assembly retaining pin.			
2.7	Grasping the forearm of the magazine adapter assembly, slide it forward and remove it from the receiver assembly.			
2.8	Depress the barrel latch, and remove the barrel assembly.			
2.9	Pull back on the cocking handle until the guide lug on the receiver is aligned with the disassembly notch on the cocking handle.			
2.10	Rotate the cocking handle upward 90° and remove.			
2.11	To remove the stock from the trigger housing group, remove the stock retaining pin.			
2.12	Rotate the bottom of the stock up and remove.			
	NOTE: The stock retaining pin, magazine adapter retaining pin, and trigger housing group retaining pin are interchangeable.			

Figure 24.3. Analysis of human performance tasks.

DATA SHEET D: MAINTENANCE AND OPERATOR TASK ANALYSIS

Card No	1 LSA Control No.	2 Task Code	3 End Item Acronym	4 Item Name	5 Mfr. Part Number	6 FSCM
D01	00	HC0XXAAM	M151A1	ENGINE, GASOLINE	346274567	22255

Line No	Sequential Task Description	Work Area	Man-Hours Minutes	Elapsed Time Minutes
01	REMOVE THE FRONT SEAT RETAINING PINS LOCATED AT THE BOTTOM OF THE TWO FRONT SEATS.		001.50	001.50
02	PULL OUT THE LOCKING PIN FROM THE BOTTOM REAR OF EACH FRONT SEAT AND REMOVE SEATS.		001.00	001.00
03	OPEN FRONT AND REAR HOLD DOWN SNAP CLIPS ON BATTERY COVER AND REMOVE COVER. LIFT COVER UP WHILE REMOVING.		001.50	001.50
04	LOOSEN NUT AND REMOVE GROUND CABLE FROM BATTERY TERMINAL POST.		000.50	000.50
05	REMOVE GEARSHIFT KNOBS. REMOVE SIX SCREWS AND LOCKWASHERS SECURING BOOT RETAINER TO TRANSMISSION COVER PLATE AND REMOVE BOOTS AND BOOT RETAINER. REMOVE TWELVE SCREWS AND LOCKWASHERS SECURING TRANMISSION COVER PLATE TO FLOOR PANEL. REMOVE TRANSMISSION PLATE.		003.00	003.00
06	LOOSEN SCREW AND NUT ON CLAMP AND REMOVE GEARSHIFT BOOT. UNSCREW CAP AND REMOVE GEARSHIFT LEVER, RETAINER, AND SPRING. TAPE CLEAN RAG OVER GEARSHIFT OPENING.		002.00	002.00
07	DISCONNECT SPEEDOMETER CABLE FROM DRIVE ADAPTER. REMOVE SPEEDOMETER CABLE FROM CLIP BENEATH STARTER. REMOVE NUT AND FLAP WASHER SECURING ELECTRICAL CABLES TO STARTER TERMINAL.		001.50	001.50
08	REMOVE TWO BOLTS AND LOCKWASHERS SECURING PARKING BRAKE LEVER TO TRANSFER CASE.		000.50	[illegible]
09	DROP LEVER FORWARD AND REMOVE TWO REAR SUPPORT MOUNTING BOLTS AND WASHERS.		001.00	[illegible]
10	REMOVE FOUR BOLTS (BOTH ENDS) SECURING FRONT PROPELLER SHAFT TO TRANSFER AND DIFFERENTIAL.		002.[illegible]	[illegible]
11	REMOVE FOUR BOLTS SECURING REAR PROPELLER SHAFT TO TRANSFER OUTPUT SHAFT FLANGE.		[illegible]	[illegible]
12	REMOVE COTTER PIN AND FLAT WASHER AND SPRING WASHER. REMOVE TRANSFER SHIFT LEVER FROM SHAFT.		003.[illegible]	[illegible]
13	REMOVE TWO LOCKNUTS AND BOLTS AT CLAMP SECURING MUFFLER INLET PIPE AND EXHAUST PIPE.		001.50	[illegible]
14	REMOVE COTTER PIN AND FLAT WASHER AND DISENGAGE CLUTCH. REMOVE TWO BOLTS AND LOCKNUTS SECURING CLUTCH RELEASE LEVER HOUSING TO HOUSING BRACKET.		[illegible]	[illegible]
15	REMOVE CLUTCH RELEASE LEVER AND HOUSING. NOTE: BE CAREFUL NOT TO LOSE TWO WASHERS, SPLIT BRASS BUSHINGS AND SPRING.		001.0[illegible]	[illegible]
16	DISCONNECT EIGHT CONNECTORS FROM HEADLIGHTS AND BLACKOUT MARKER LIGHTS.		000.50	[illegible]
17	REMOVE SIX SCREWS AND LOCKWASHER ASSEMBLIES (AND SIX WASHERS) SECURING BRUSH GUARD TO FENDERS. REMOVE BRUSH GUARD.		[illegible]	[illegible]
	CONTINUED ON THE NEXT PAGE			

Card No	SSC A	SSC B	SSC C	SSC D	SSC E	SSC F	SSC G	SSC H
D	3020	6300						

Card No	Man-Hours A	Man-Hours B	Man-Hours C	Man-Hours D	Man-Hours E	Man-Hours F	Man-Hours G	Man-Hours H	Total Elapsed Time
D	240.00	240.00							240.00

Figure 24.4. Data Sheet D.

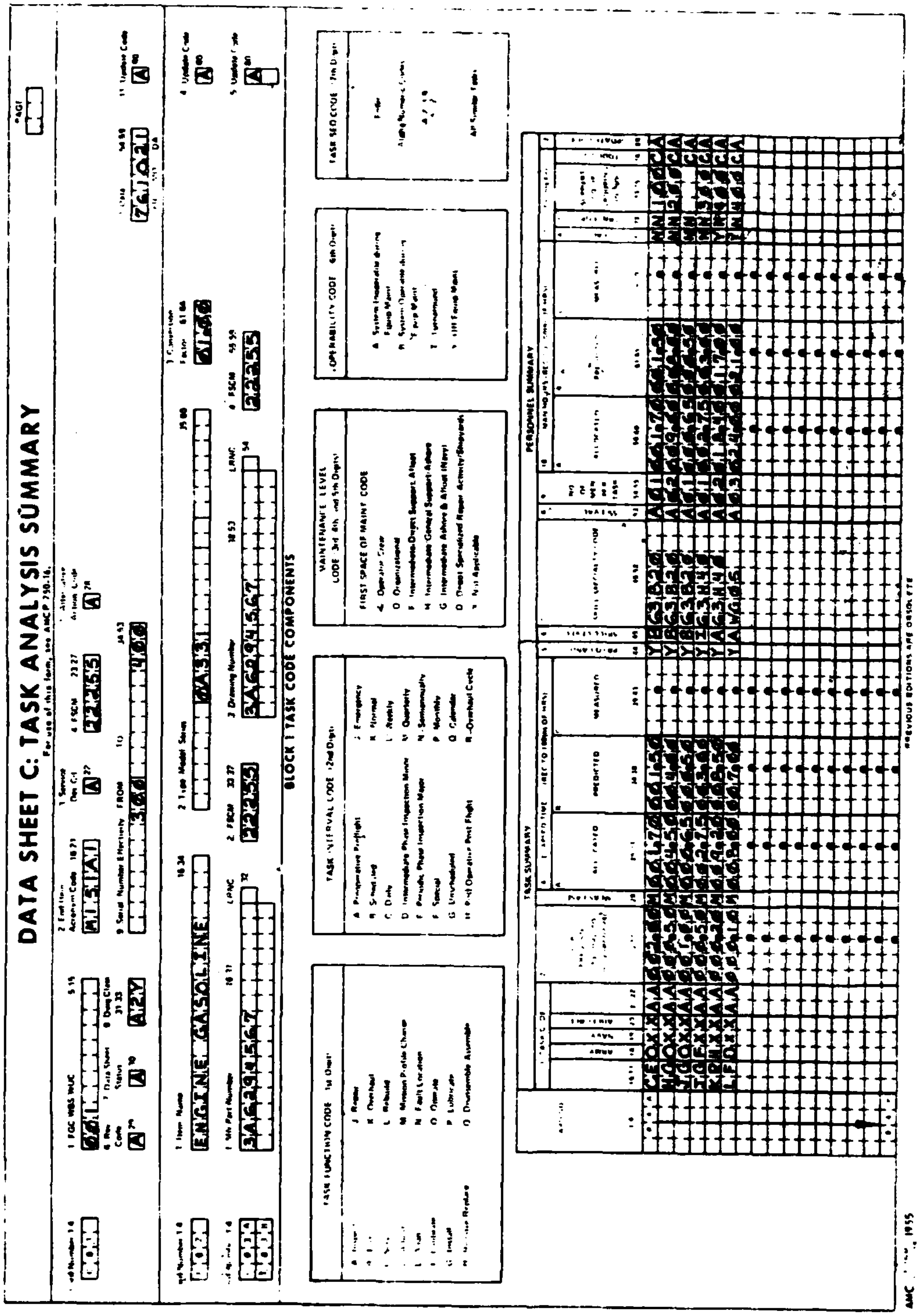


Figure 24.5. Data Sheet C

EXAMPLE LSAR/HFE COMPUTER OUTPUT FORM

END ITEM ACRONYM CODE - M151A
SYSTEM - XXX
SUBSYSTEM - XXX
COMPONENT - XXX
WORK AREA - XXX
DRAWING NUMBER(S) - XXX

TASK IDENTIFICATION - REMOVE AND REPLACE ENGINE
WORK CATEGORY CODE - XXX
MAINTENANCE (LEVEL) CODE - ORGANIZATIONAL

MAN ID	PERSONNEL POSITION	SKILL SPECIALTY CODE REQUIRED	SKILL LEVEL REQUIRED	SKILL SPECIALTY EVALUATION
X	XXX	XXX	XXX	XXX
Y	XXX	XXX	XXX	XXX

MAN ID	SEQUENCE LINE NUMBER (SLN)	SEQUENTIAL TASK DESCRIPTION (NARRATIVE)	TASK HIERARCHY LEVEL	TASK NUMBER	SLN SIMULTANEOUS UNIT OF WORK	TOOLS EQUIPMENT AND AIDS	PERFORMANCE STANDARDS	ELAPSED TIME ALLOCATED	ELAPSED TIME ESTIMATED	MEASURED EFT	MEASURED ECT	STANDARD DEVIATION	TEST PARTICIPANTS	ERROR RATE
	1	REMOVE AND REPLACE ENGINE	FA					XXX	XXX	XXX	XXX	XXX	10	XX
X	2	TASK A	T	XXX	7			XXX	XXX	XXX	XXX	XXX	5	XX
	3	SUBTASK A1	ST						XXX	XXX	XXX	XXX		XX
	4	TASK ELEMENT A1a	TE			XXX	XXX			XXX	XXX	XXX		XX
	5	TASK ELEMENT A1b	TE			XXX				XXX	XXX	XXX		XX
	6	SUBTASK A2	ST			XXX			XXX	XXX	XXX	XXX		XX
	14	TASK E	T	XXX		XXX		XXX	XXX	XXX	XXX	XXX		XX
	15	TASK F	T	XXX				XXX	XXX	XXX	XXX	XXX		XX
	16	SUBTASK F1	ST			XXX			XXX	XXX	XXX	XXX		XX
	17	SUBTASK F2	ST			XXX			XXX	XXX	XXX	XXX		XX
Y	7	TASK B	T	XXX	2			XXX	XXX	XXX	XXX	XXX	5	XX
	8	SUBTASK B1	ST			XXX			XXX	XXX	XXX	XXX		XX
	9	SUBTASK B2	ST						XXX	XXX	XXX	XXX		XX
	10	TASK ELEMENT B2a	TE			XXX				XXX	XXX	XXX		XX
	11	TASK ELEMENT B2b	TE			XXX	XXX			XXX	XXX	XXX		XX
	12	TASK C	T	XXX		XXX		XXX	XXX	XXX	XXX	XXX		XX
	13	TASK D	T	XXX		XXX		XXX	XXX	XXX	XXX	XXX		XX

SLN	PERFORMANCE STANDARDS DESCRIPTION
4	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
11	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Figure 24.6. Example LSAR/HFE computer output form.

LESSON 25: AFFORDABILITY, OR WHEN CAN WE TRADE OFF WHAT?

Lesson 25 discusses the issues which arise when a system must be evaluated in two or more aspects, i.e., cost versus functional aspects.

OUTLINE

I. Trade-off Analysis

   A. Definition
   B. Types:

      1. Geometry of design
      2. Manpower allocation

II. General System Analysis

   A. Operational requirement
   B. Hardware design
   C. Manpower and training requirements
   D. Safety, reliability, and other factors

III. Four Major Steps in Trade-off Analysis:

   A. Baseline alternative

      1. ROC
      2. Initial hardware concepts and resource estimates
      3. Manpower and training requirements
      4. Estimate life-cycle costs

   B. Identify alternative equipment designs
   C. Analysis of resource requirements
   D. Select the preferred alternative

IV. Life-cycle Costs

   A. Computer models

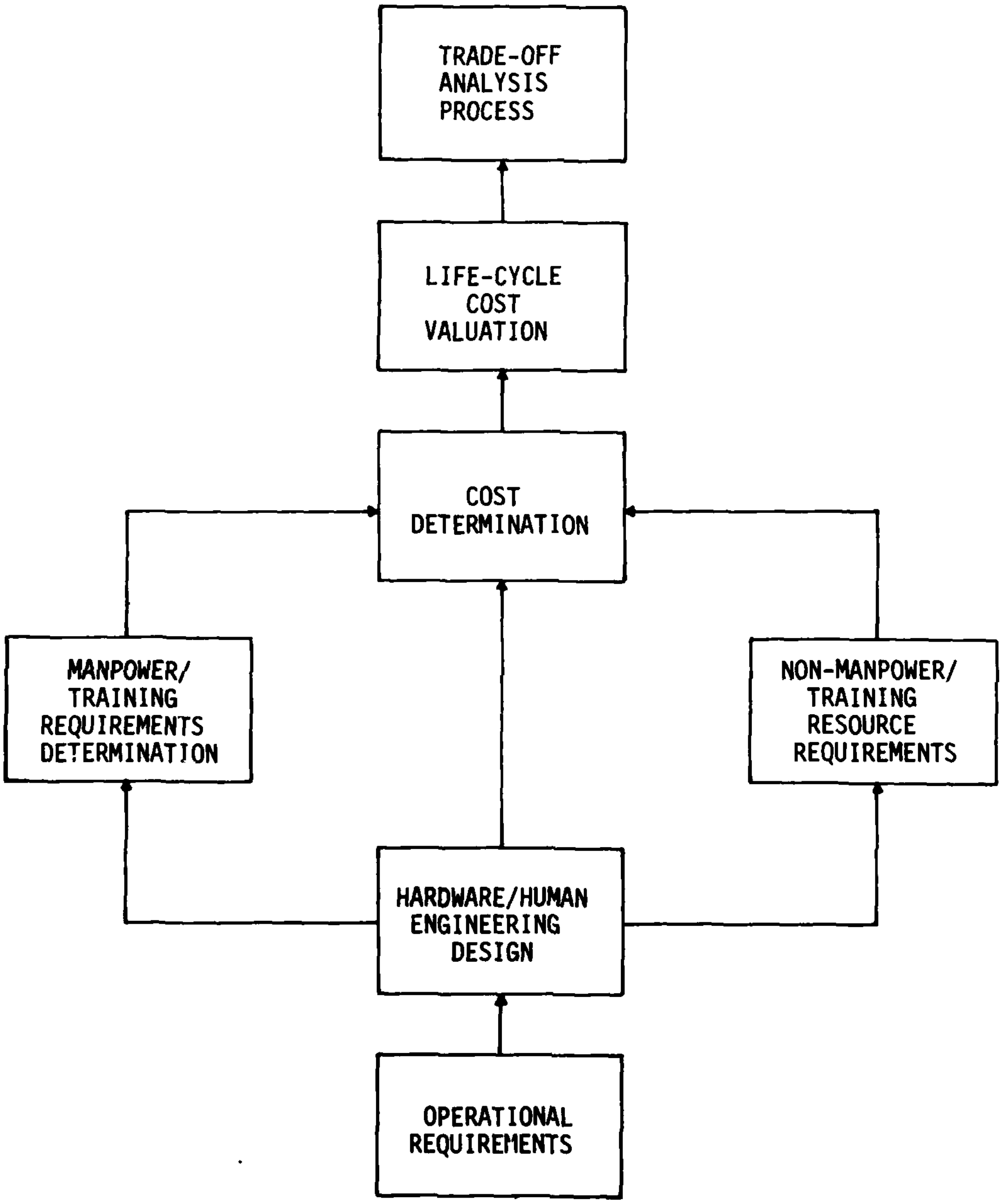


Figure 25.1. Conceptual process flow of a trade-off analysis module.

STEPS

I. Establish System Baseline Alternative (Alt Ø)

<u>Procedure</u>:

Operational Requirement → Hardware Concept and Resource Estimate → Manpower/ Training Requirements → Life-cycle Costing (LCC) → Alt Ø (Baseline)

Hardware Concept and Resource Estimate → Life-cycle Costing (LCC)

II. Generate System Alternatives

<u>Procedure</u>:

a. With respect to any of the following, specify alternative systems hardware or software systems designs:

i. Subsystems
ii. Design Concept
iii. Maintenance Concept
iv. Technology employed
v. Integrated Logistics Support Concept

b. Specify the alternatives selected for analysis

III. For each system alternative, estimate manpower/training (M/T) requirements and life cycle cost (LCC) and array in alternatives table. Specify strengths and weaknesses (S&W) with respect to satisfying top level specifications and operational requirements.

Alternative	M Rqmts	T Rqmts	LCC	S&W
Ø (Base)				
1				
2				
3				
4				

IV. Select the preferred alternative. Record the rationale for selection.

The preferred alternative becomes the system baseline (Alt Ø) for subsequent iterations of trade-off analysis.

Figure 25.2. Summary of the four major steps involved in a typical hardware trade-off analysis.

LESSON 26: MAINTAINABILITY, OR CAN ANYBODY FIX THIS?

Every system requires operators and maintainers. Lesson 26 examines the human factors emphasis from the maintainer's viewpoint. The concepts of reliability and maintainability are discussed relative to the design phase of system acquisition.

OUTLINE

I. Basic Concepts

   A. Maintainability
   B. Maintenance
   C. Reliability
   D. Human Performance

II. Design Features

III. Skill Application

   A. Capabilities/limitations
   B. Training

IV. Predictions

LESSON 27: HAZARD ANALYSIS, OR A STITCH IN TIME

In this lesson you will be introduced to general hazard analysis. Remember that the chief aims of human factors engineering are: (1) to increase the effectiveness of man's interaction with his equipment by proper design and (2) through this design process, to enhance human values. This lesson specifically deals with these two aims by addressing the safety of the individual.

OUTLINE

I. Introduction

   A. HFE and safety
   B. HFE and safety design

II. Introduction To Hazard Analysis

III. Identification Phase

   A. Checklists
   B. Historical records - intermediate indicators
   C. General investigations

IV. Evaluation Phase

   A. Grouping according to category
   B. Ranking within category

V. Cost Countermeasures

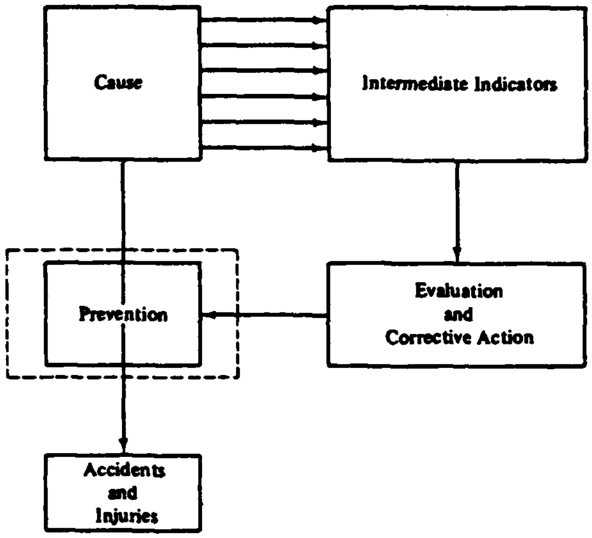


Figure 27.1. Methodology by which intermediate indicators lead to accident prevention. (Brown, 1976).

In this figure it can be seen that accidents (cause) will result in intermediate indicators which, if taken into consideration, will lead to accident prevention.

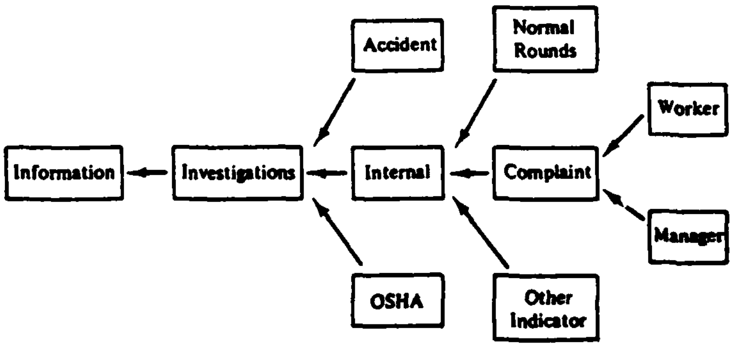


Figure 27.2. Sources of information outline (Brown, 1976).

Figure 27.2 represents a broad model of the various sources of information used in accident investigation and prevention.

GENERAL HAZARD ANALYSIS CARD No. ________

Prepared by ____________________ Date ____________________

Hazard Description ____

Departments:

Severity	Probability	Cost	Action
O Nuisance	O Unlikely	O Prohibitive	O Defer
O Marginal	O Probable	O Extreme	O Analysis
O Critical	O Considerable	O Significant	O Immediate
O Catastrophic	O Imminent	O Nominal	Date ______

Figure 27.3. Example of a "hazard card." (Brown, 1976).

Hazard analysis can be conducted in a variety of manners. Figure 27.3 represents one method of summarizing accident or hazard information. This figure also represents a method to aid in the decision-making process.

LESSON 28: TRAINING THE RIGHT PEOPLE

In order to have a man-machine system you must have personnel. Lessons 28 and 29 deal with the topics of personnel selection and training. In lesson 28 you will learn about the processes of personnel selection as well as types of training methods.

OUTLINE

I. Selection and Training in Design/Conceptual Phase

   A. Approaches:

      1. Organizational Analysis
      2. Job analysis
      3. Person analysis

II. Training Techniques

   A. On-the-job training
   B. Classroom training
   C. Computer-aided instruction
   D. Team training

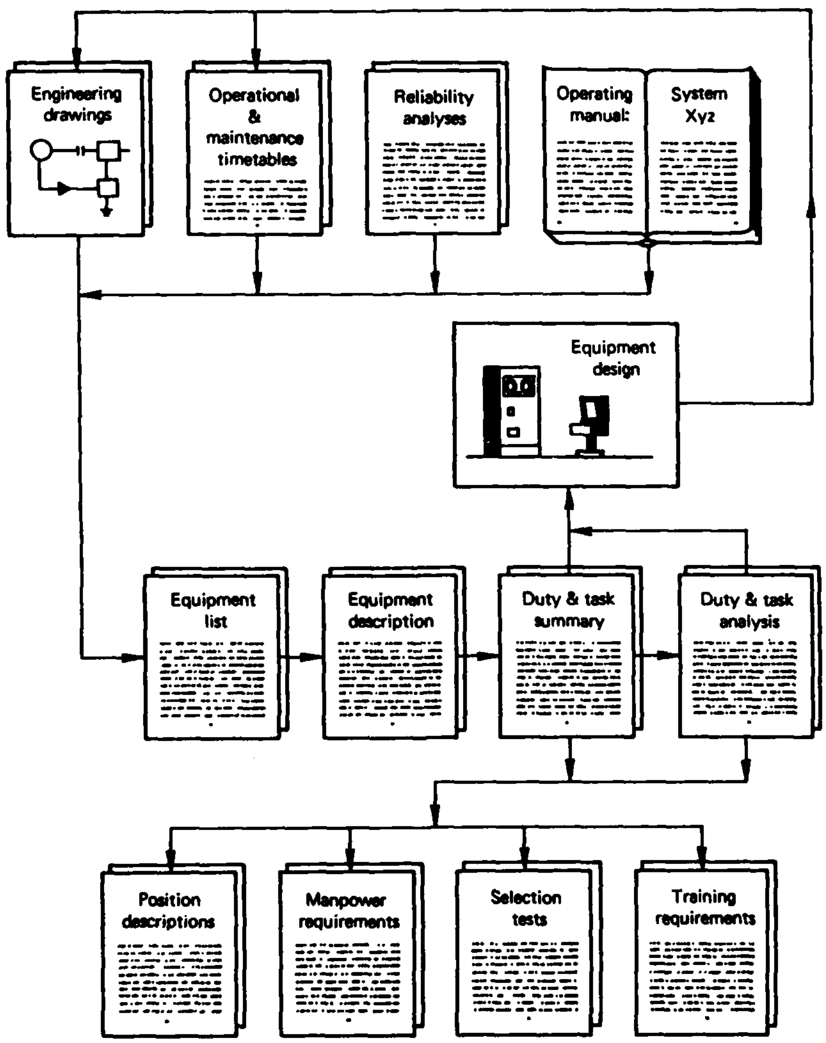


Figure 28.1. A systems-staffing flowchart. Top row, source documents; middle row, worksheets; bottom row, end results of systems staffing. (From De Greene, 1970)

LESSON 29: DOES TRAINING WORK?

This lesson continues the training section of your course in human factors engineering. In lesson 29 you will learn about the instructional systems development technique for training development. You will also discuss the evaluation of training programs.

OUTLINE

I. ISD Phases

   A. Analyze
   B. Design
   C. Develop
   D. Implement
   E. Control

II. Validity and Reliability

   A. Types of validity

      1. Training
      2. Performance
      3. Intra-organizational
      4. Inter-organizational

III. Simulator Training Issues

Phase I

ANALYZE

Inputs, processes, and outputs in Phase I are all based on job information. An inventory of job tasks is compiled and divided into two groups; tasks not selected for instruction and tasks selected for instruction. Performance standards for tasks selected for instruction are determined by interview or observation at job sites and verified by subject matter experts. The analysis of existing course documentation is done to determine if all or portions of the analysis phase and other phases have already been done by someone else following the ISD guidelines. As a final analysis phase step, the list of tasks selected for instruction is analyzed for the most suitable instructional setting for each task.

Phase II

DESIGN

Beginning with Phase II, the ISD model is concerned with designing instruction using the job analysis information from Phase I. The first step is the conversion of each task selected for training into a terminal learning objective. Each terminal learning objective is then analyzed to determine learning objectives and learning steps necessary for mastery of the terminal learning objective. Tests are designed to match the learning objectives. A sample of students is tested to insure that their entry behaviors match the level of learning analysis. Finally, a sequence of instruction is designed for the learning objectives.

Phase III

DEVELOP

The instructional development phase begins with the classification of learning objectives by learning category so as to identify learning guidelines necessary for optimum learning to take place. Determining how instruction is to be packaged and presented to the student is accomplished through a media selection process which takes into account such factors as learning category and guideline, media characteristics, training setting criteria, and costs. Instructional management plans are developed to allocate and manage all resources for conducting instruction. Instructional materials are selected or developed and tried out. When materials have been validated on the basis of empirical data obtained from groups of typical students, the course is ready for implementation.

Phase IV

IMPLEMENT

Staff training is required for the implementation of the instructional management plan and the instruction. Some key personnel must be trained to be managers in the specified management plan. The instructional staff must be trained to conduct the instruction and collect evaluative data on all of the instructional components. At the completion of each isntructional cycle, management staff should be able to use the collected information to improve the instructional system.

Phase V

CONTROL

Evaluation and revision of instruction are carried out by personnel who preferably are neither the instructional designers nor the managers of the course under study. The first activity (internal evaluation) is the analysis of learner performance in the course to determine instances of deficient or irrelevant instruction. The evaluation team then suggests solutions for the problems. In the external evaluation, personnel assess job task performance on the job to determine the actual performance of course graduates and other job incumbents. All collected data, internal and external, can be used as quality control on instruction and as input to any phase of the system for revision.

Figure 29.1. The five ISD phases.

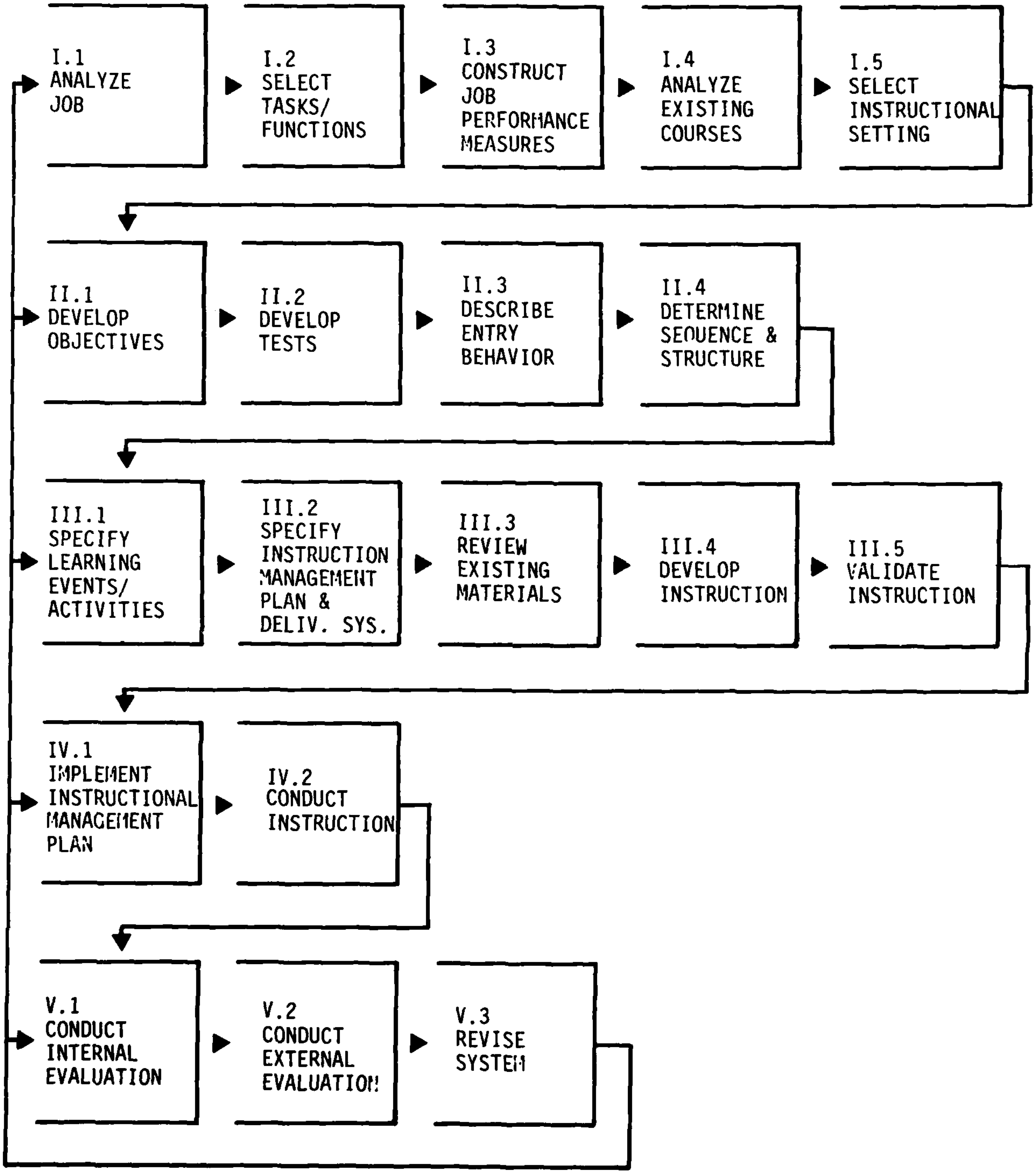


Figure 29.2. The blocks in each ISD phase.

I

.1...a list of tasks performed in a particular job.

.2...a list of tasks selected for training.

.3...a job performance measure for each task selected for instruction.

.4...an analysis of the job analysis, task selection, and performance measure construction for any existing instruction to determine if these courses are usable in whole or in part.

.5...selection of the instructional setting for task selected for instruction.

II

.1...a learning objective for a learning analysis of each task selected for instruction.

.2...test items to measure each learning objective.

.3...a test of entry behaviors to see if the original assumptions were correct.

.4...the sequencing of all dependent tasks.

III

.1...the classification of learning objectives by learning category and the identification of appropriate learning guidelines.

.2...the media selections for instructional development and the instructional management plan for conducting the instruction.

.3...the analysis of packages of any existing instruction that meets the given learning objectives.

.4...the development of instruction for all learning objectives where existing materials are not available.

.5...field tested and revised instructional materials.

IV

.1...documents containing information on time, space, student and instructional resources, and staff trained to conduct the instruction.

.2...a complete cycle of instruction with information needed to improve it for the succeeding cycle.

V

.1...data on instructional effectiveness.

.2...data on job performance in the field.

.3...instructional system revised on basis of empirical data.

Figure 29.3. The outcomes of the blocks in each of the ISD phases.

LESSON 30: PSYCHOPHYSICAL METHODS, OR DO I DETECT A SIGNAL?

In order to interact with his environment, man must sense and perceive the variety of stimuli impinging upon him. Lesson 30 presents the various types of psychophysical methods and their uses.

OUTLINE

I. Psychophysics:

   A. Definition
   B. Purpose

II. Classical Methods

   A. Methods of limits, adjustment and constant stimuli
   B. Assumptions
   C. Advantages, disadvantages

III. Theory of Signal Detectability

   A. Response bias
   B. Decision matrix

IV. Scaling Methods

   A. Direct
   B. Indirect

OBSERVER'S RESPONSE

STIMULUS		YES	NO
	ON	HIT	MISS
	OFF	FALSE ALARM	CORRECT REJECTION

Figure 30.1. The four possible events in a signal detection experiment.

Lesson 31: EXPERIMENTAL METHODS, OR HOW DO I KNOW IF I'VE DONE IT RIGHT?

The major research categories will be presented in this lesson. In addition, the types of variables found in experimentation are defined.

OUTLINE

I. Eager's Experiment

II. Research Categorization

- A. Theoretical
- B. Empirical
    1. Observation, correlation, experimentation
    2. Natural (field), laboratory

III. Variable Classifications

- A. Qualitative and quantitative
- B. Independent, dependent
- C. Relevant
    1. Subject
    2. Situational
    3. Sequence

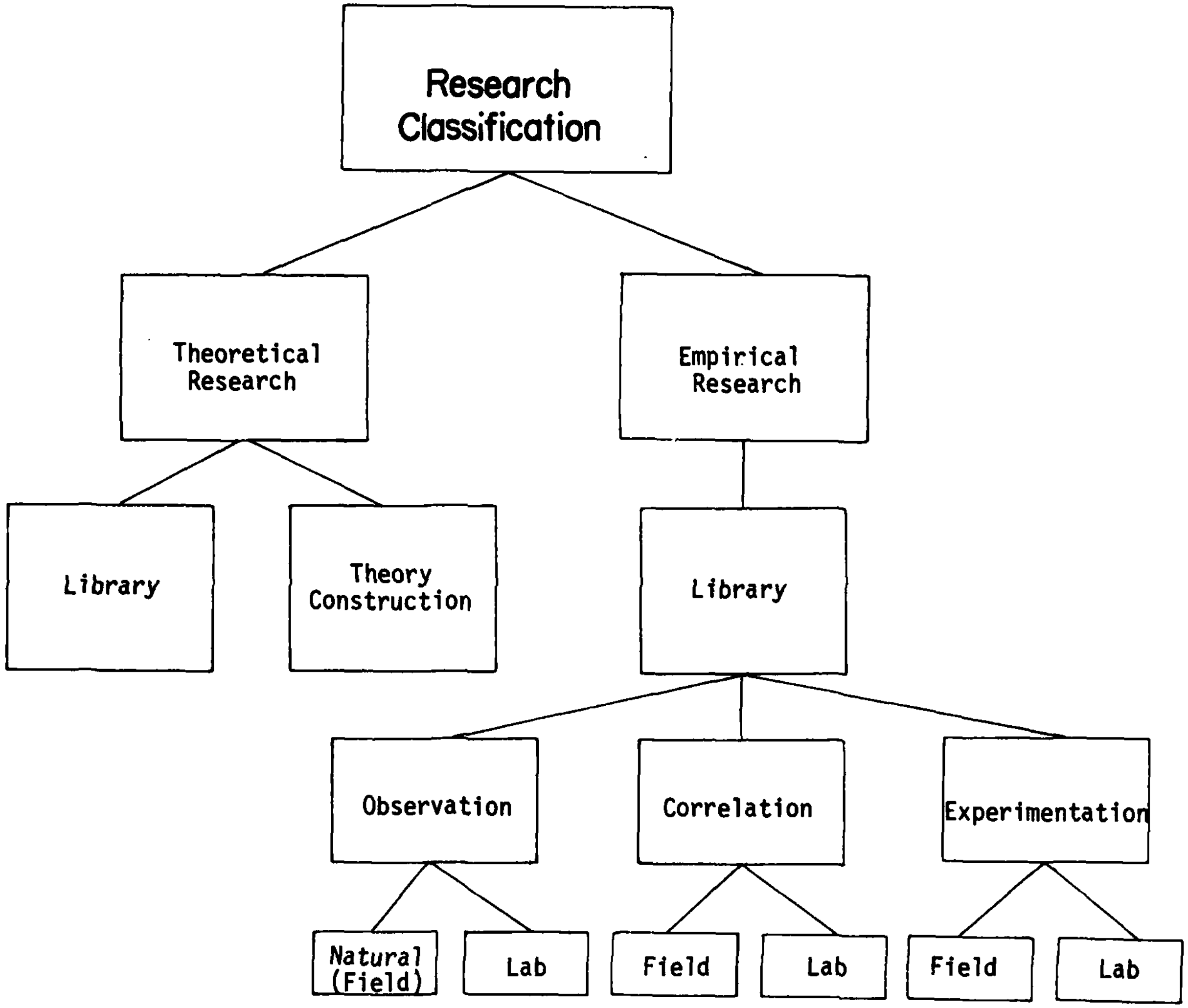


Figure 31.1. Major categories of research.

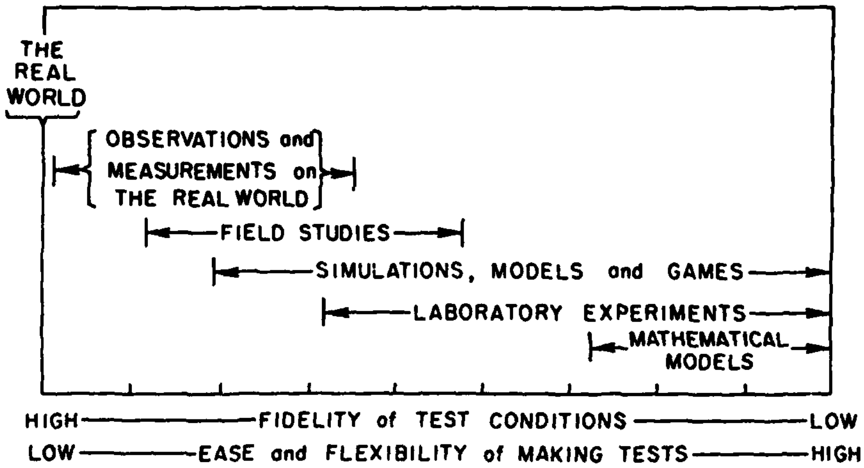


Figure 31.2. The fidelity of various test techniques and the flexibility with which they may be applied. (From Meister and Rabideau, 1965.)

LESSON 32: EXPERIMENTAL METHODS, OR HOW DO I CONTROL THESE INFLUENCES?

The different types of experimental design are presented along with techniques to control the unwated effects of relevant variables. The concepts of validity are also discussed.

OUTLINE

I. Control Techniques

   A. Subject
   B. Situational
   C. Sequence

II. Designs

   A. Within subject
   B. Between subjects

      1. Simple randomized
      2. Factorial

III. Validity

   A. Internal
   B. External

Table 32.1. Within subjects design

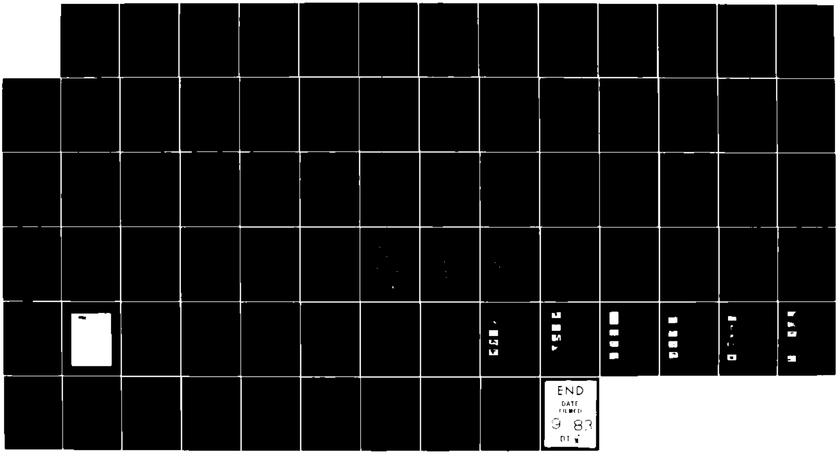
	MUSIC					
	ROCK	DISCO	COUNTRY	POLKA	CLASSICAL	MOOD
SUBJECT	Subject #1	Subject #1	Subject #1	Subject #1	Subject #1	Subject #1
	" #2	" #2	" #2	" #2	" #2	" #2
	" #3	" #3	" #3	" #3	" #3	" #3
	" #4	" #4	" #4	" #4	" #4	" #4
	" #5	" #5	" #5	" #5	" #5	" #5
	" #6	" #6	" #6	" #6	" #6	" #6
	" #7	" #7	" #7	" #7	" #7	" #7
	" #8	" #8	" #8	" #8	" #8	" #8
	" #9	" #9	" #9	" #9	" #9	" #9
	" #10	" #10	" #10	" #10	" #10	" #10

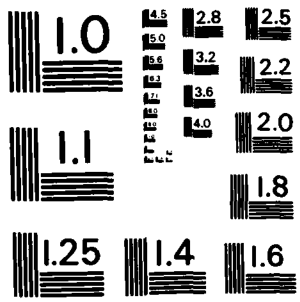
Table 32.2. Between subjects design

	MUSIC					
	ROCK	DISCO	COUNTRY	POLKA	CLASSICAL	MOOD
SUBJECT	Subject #1	Subject #11	Subject #21	Subject #31	Subject #41	Subject #51
	" #2	" #12	" #22	" #32	" #42	" #52
	" #3	" #13	" #23	" #33	" #43	" #53
	" #4	" #14	" #24	" #34	" #44	" #54
	" #5	" #15	" #25	" #35	" #45	" #55
	" #6	" #16	" #26	" #36	" #46	" #56
	" #7	" #17	" #27	" #37	" #47	" #57
	" #8	" #18	" #28	" #38	" #48	" #58
	" #9	" #19	" #29	" #39	" #49	" #59
	" #10	" #20	" #30	" #40	" #50	" #60

AD-A132 555 HUMAN FACTORS ENGINEERING STUDENT SUPPLEMENT(U) HUMAN ENGINEERING LAB ABERDEEN PROVING GROUND MD R BROGAN ET AL. AUG 81 2/2

UNCLASSIFIED F/G 5/5 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Table 32.3. Factorial design

SEX		ROCK	DISCO	COUNTRY	CLASSICAL	POLKA	MOOD
SEX	MALE	Subject #1 " #2 " #3 " #4 " #5 " #6 " #7 " #8 " #9 " #10	Subject #11 " #12 " #13 " #14 " #15 " #16 " #17 " #18 " #19 " #20	Subject #21 " #22 " #23 " #24 " #25 " #26 " #27 " #28 " #29 " #30	Subject #31 " #32 " #33 " #34 " #35 " #36 " #37 " #38 " #39 " #40	Subject #41 " #42 " #43 " #44 " #45 " #46 " #47 " #48 " #49 " #50	Subject #51 " #52 " #53 " #54 " #55 " #56 " #57 " #58 " #59 " #60
	FEMALE	Subject #1 " #2 " #3 " #4 " #5 " #6 " #7 " #8 " #9 " #10	Subject #11 " #12 " #13 " #14 " #15 " #16 " #17 " #18 " #19 " #20	Subject #21 " #22 " #23 " #24 " #25 " #26 " #27 " #28 " #29 " #30	Subject #31 " #32 " #33 " #34 " #35 " #36 " #37 " #38 " #39 " #40	Subject #41 " #42 " #43 " #44 " #45 " #46 " #47 " #48 " #49 " #50	Subject #51 " #52 " #53 " #54 " #55 " #56 " #57 " #58 " #59 " #60

LESSON 33: STATISTICS, PART I

Lessons 33 and 34 will provide you with information about statistics so that you may make meaningful interpretations about data that you will work with. This lesson (33) concentrates on the descriptive use of statistics.

OUTLINE

I. Intro:

   A. Description of total statistics lessons
   B. Description of Statistics
   C. Purpose of Statistics

II. Frequency Distributions

   A. Ungrouped data
   B. Internal data
   C. Meaning of any one score
   D. Percentile ranks

III. Measures of Central Tendency

   A. Mean
   B. Normal curve
   C. Median

IV. Measures of Despersion

   A. Mean deviation
   B. Standard deviation
   C. Variance
   D. Relation of 50 and normal curve

Table 33.1. Random arrangement of 120 scores

13	7	6	16	9	3	12	13	11	14	5	10	4	9	7
9	17	14	13	11	12	19	4	9	7	12	16	7	12	11
4	5	11	17	10	9	10	17	13	16	12	13	18	9	15
16	12	9	7	14	3	16	9	5	10	17	15	11	10	10
6	18	10	15	8	13	14	18	12	8	9	8	12	8	12
11	8	11	12	16	11	7	15	11	14	20	7	6	14	16
5	15	19	14	13	15	8	8	13	11	7	11	12	17	13
14	10	13	8	5	17	11	10	6	12	5	1	11	8	10

Table 33.2. Ordered arrangement of 120 scores

20	17	16	15	14	13	12	11	11	10	9	8	7	6	5
19	17	16	14	13	13	12	11	11	10	9	8	7	6	5
19	17	16	14	13	13	12	11	11	10	9	8	7	6	4
18	17	15	14	13	12	12	11	11	10	9	8	7	6	4
18	16	15	14	13	12	12	11	10	10	9	8	7	5	4
18	16	15	14	13	12	12	11	10	10	9	8	7	5	3
17	16	15	14	13	12	12	11	10	9	9	8	7	5	3
17	16	15	14	13	12	11	11	10	9	8	8	7	5	1

Table 33.3. Frequency distribution of ungrouped scores

X	f
20	1
19	2
18	3
17	6
16	7
15	6
14	8
13	10
12	12
11	13
10	10
9	9
8	9
7	8
6	4
5	6
4	3
3	2
2	0
1	1
0	0

Table 33.4. Frequency distribution of 120 grouped scores

X	f
17–20	12
13–16	31
9–12	44
5–8	27
1–4	6

Table 33.5. Percentile ranks of 120 scores

X	f	cf	PR
20	1	120	99.6
19	2	119	98.3
18	3	117	96.2
17	6	114	92.5
16	7	108	87.1
15	6	101	81.7
14	8	95	75.8
13	10	87	68.3
12	9	77	59.2
11	9	65	48.7
10	8	52	39.2
9	4	42	31.2
8	6	33	23.7
7	3	24	16.7
6	2	16	11.7
5	0	12	7.5
4	1	6	3.7
3		3	1.7
2		1	0.8
1		1	0.4

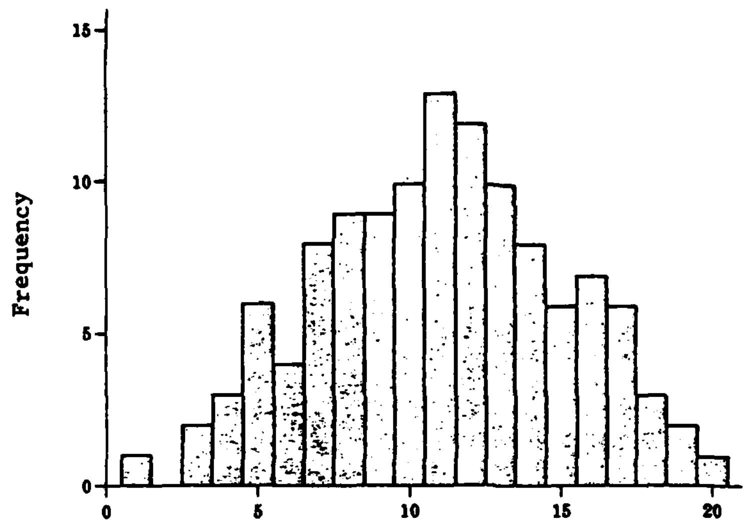


Figure 33.1. Histogram of 120 Response Speeds

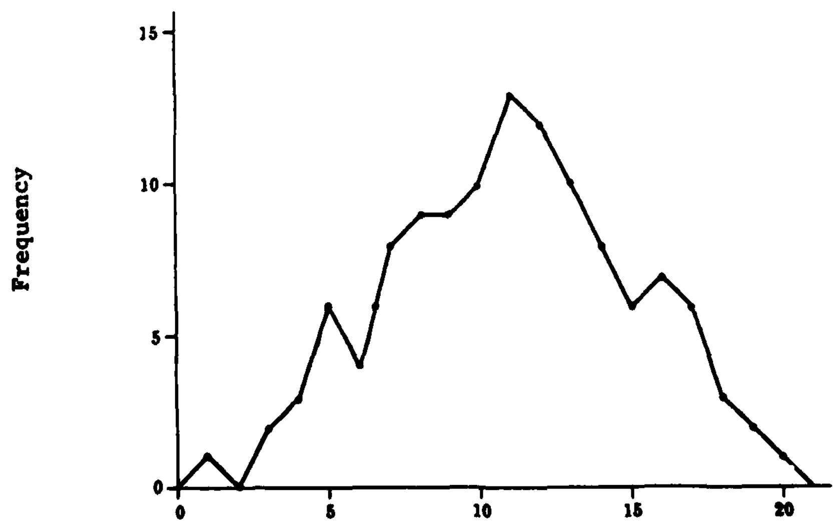


Figure 33.2. Frequency Polygon of 120 Response Speeds

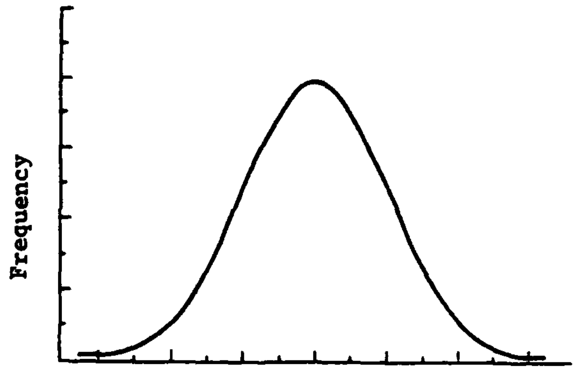


Figure 33.3. The normal curve.

Table 33.6. Speed (in seconds) that it took 120 individuals to grasp a series of four knobs

Score	Deviations from M	X	X^2
10	3.6	3.6	12.96
9	2.6	2.6	6.76
8	1.6	1.6	2.56
7	.6	.6	.36
7	.6	.6	.36
6	-.4	.4	.16
6	-.4	.4	.16
5	-1.4	1.4	1.96
4	-2.4	2.4	5.76
2	-4.4	4.4	19.36
64	0	18	50.4

M = 6.4
Mean Deviation = 1.8
SD = 2.37
V = 5.04

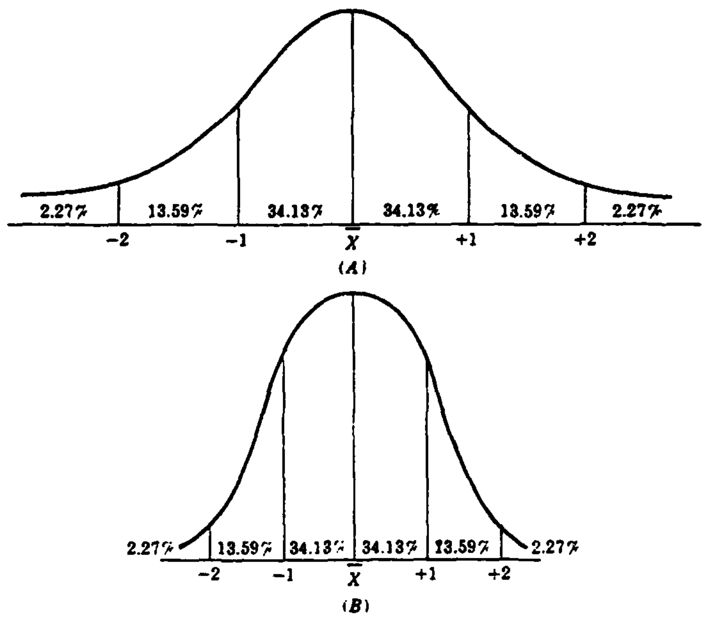


Figure 33.4. Areas under the normal curve

LESSON 34: STATISTICS, PART II

In lesson 33 you learned how to describe your data by use of the appropriate statistics. This lesson will show you how to interpret your data and how to draw inferences from your research findings.

OUTLINE

I. Correlation

- A. Degree
- B. Direction

II. Inferential Statistics

- A. Nonparametric
- B. Parametric
- C. Appropriate statistical tests
    1. t
    2. F
    3. ANOVA

III. Interpretation of Results

- A. Practical vs. statistical significance
- B. One-way ANOVA
- C. Two-way ANOVA
- D. Higher order ANOVAs

MEASUREMENT SCALES

Measurement is the systematic application of numbers to data according to prescribed procedures and rules. These procedures and rules relate to the arithmetic operations which can be legitimately used on the data. The increasing levels of measurement scales reflect the increasing mathematical operations which can be performed. The scales and their permissible operations are presented below.

(1) Nominal measurement - This is the lowest level of measurement. The scales consist of sorting observations into categories or classes. Identification numbers and numbers on athletic uniforms are examples of this type of scale.

(2) Ordinal measurement - This type of measurement provides an ordering of observations according to magnitude. Being first in a race is better than being second. However, these scales do not reveal anything about the distances between any two points on the scale; they don't tell you how far ahead the first place score was from the second place score.

(3) Interval measurement - A scale which contains interval measures is one in which there are equal intervals between the units of measure. For example, a temperature scale has equal amounts of distance between each scale marker so that a temperature of 50 falls half way between 40 and 60 degrees. It is possible with this type of scale to perform mathematical operations such as addition and subtraction.

(4) Ratio scales have all the properties of the other scales, but it addition there is an absolute zero. Temperatures can fall below zero on both the Fahrenheit and Centigrade scales, but variables such as height and weight have an absolute zero and, therefore, one ratio in nature.

When deciding which type of statistical procedure to employ you need to distinguish between parametric or nonparametric ones. These distinctions will be explained in your lesson. For your information, however, a list of the two types of statistical procedures along with their measurement levels is provided below:

Parametric	Nonparametric
t test - interval	Chi-square - nominal
F test - interval	Cochran Q - nominal
ANOVA - interval	Mann Whitney-U - ordinal
	Wilcoxon - ordinal
	Kruskal-Wallis - ordinal
	Friedman - ordinal

Table 34 in this supplement section will help you to decide which statistical test to compute when you are testing hypotheses about means or variances and you have data from 1, 2, or 3 groups. Figure 1 doesn't provide as many examples as we just listed but does give you the most commonly used tests.

Table 34.1. Statistical tests

TYPES		COMPARISONS	
	Means(2)	Means(2+)	Variances(2)
Parametric	T-Test	ANOVA	F
Nonparametric	Mann Whitney-U, Wilcoxon	Kruskal-Wallis, Friedman	- -

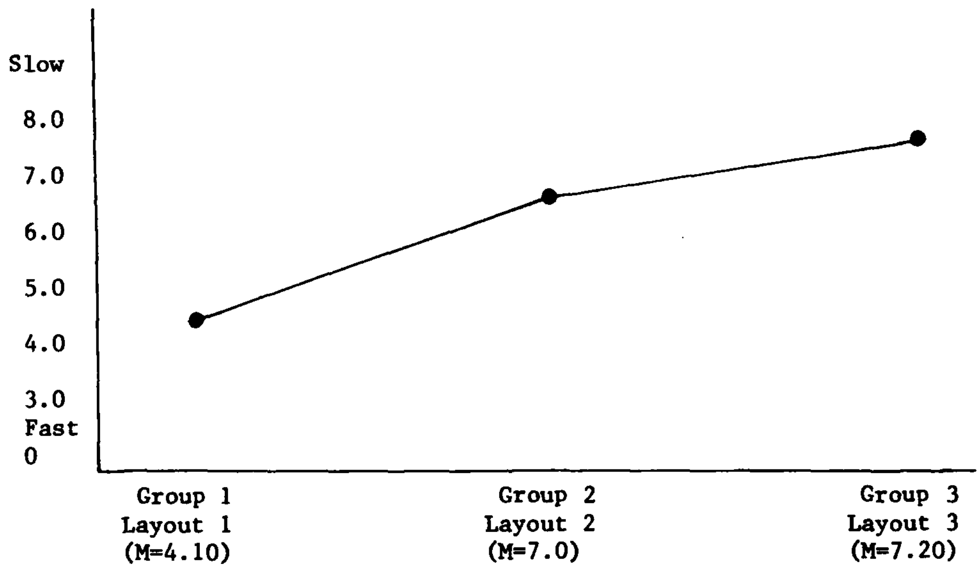


Figure 34.1. Response speeds obtained under three difficulty levels of configuration layouts.

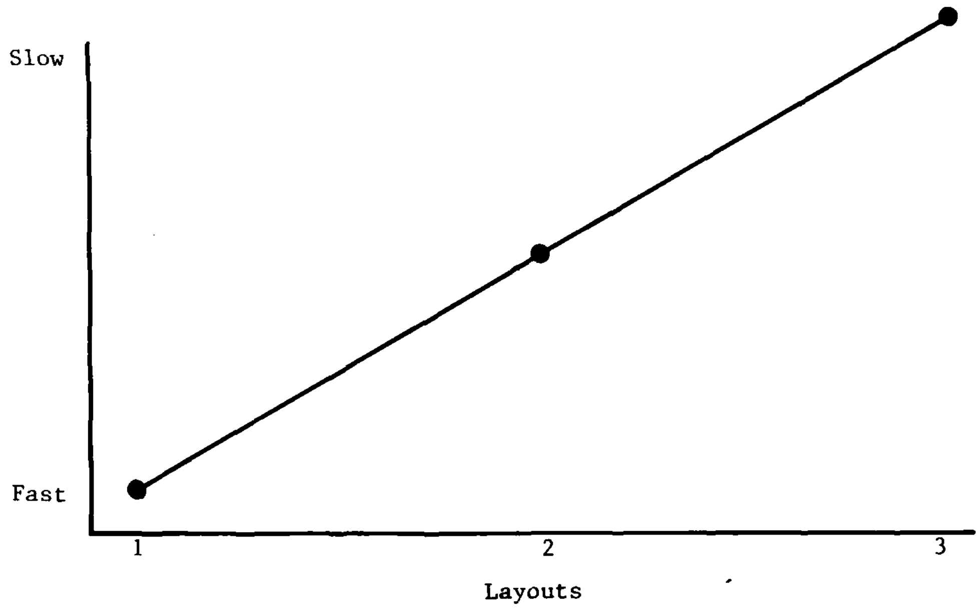


Figure 34.2A. Response speed given changes in layout.

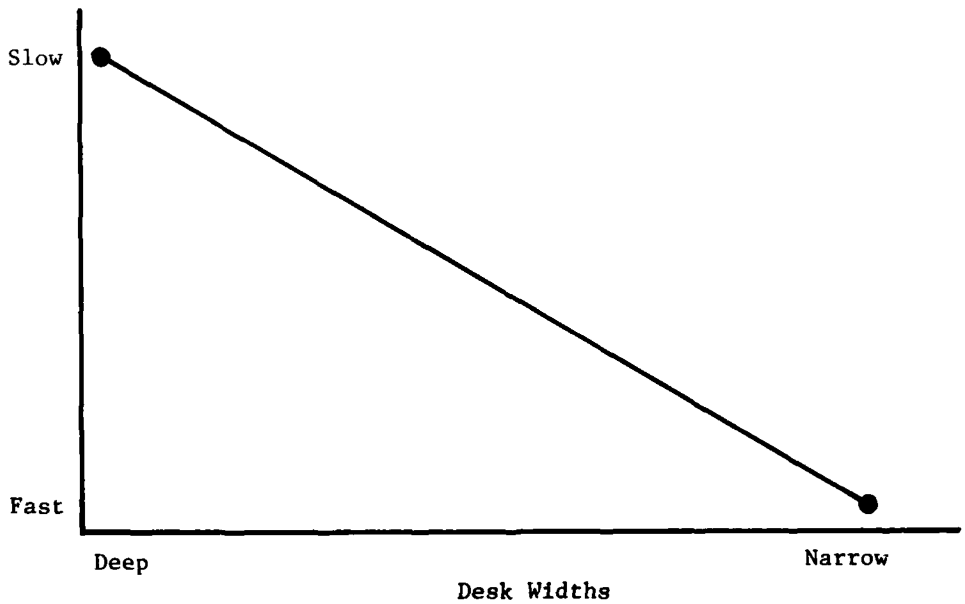


Figure 34.2B. Change in response speed given different desk widths.

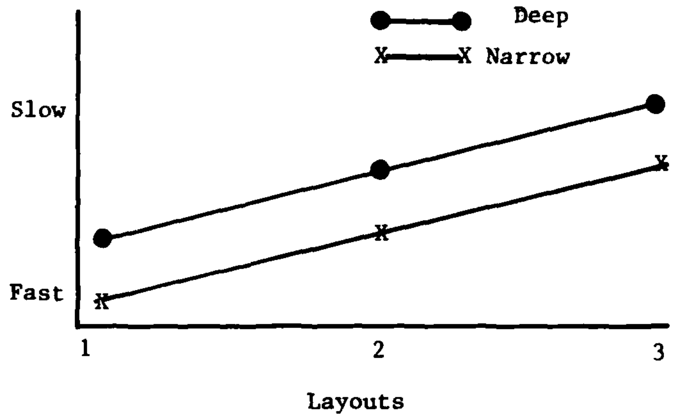


Figure 34.2 C. Changes in response speed given the interaction of desk width and layout.

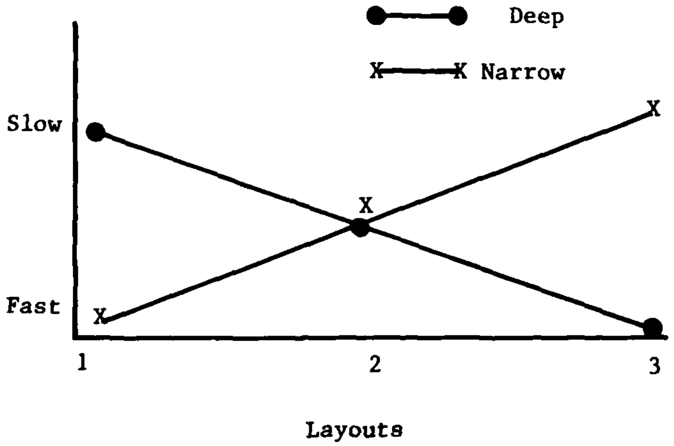


Figure 34.2 D. Changes in response speed given the interaction of desk width and layout.

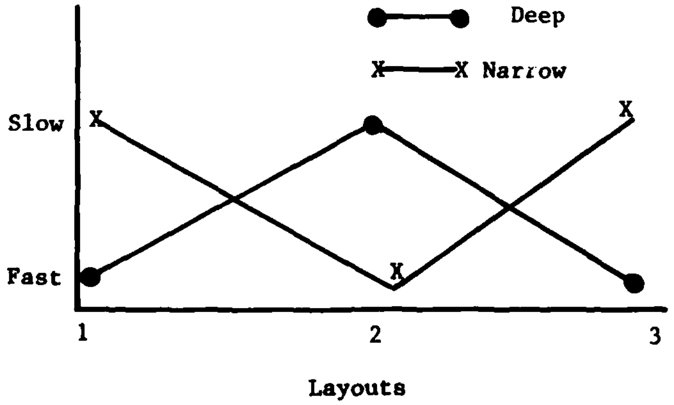
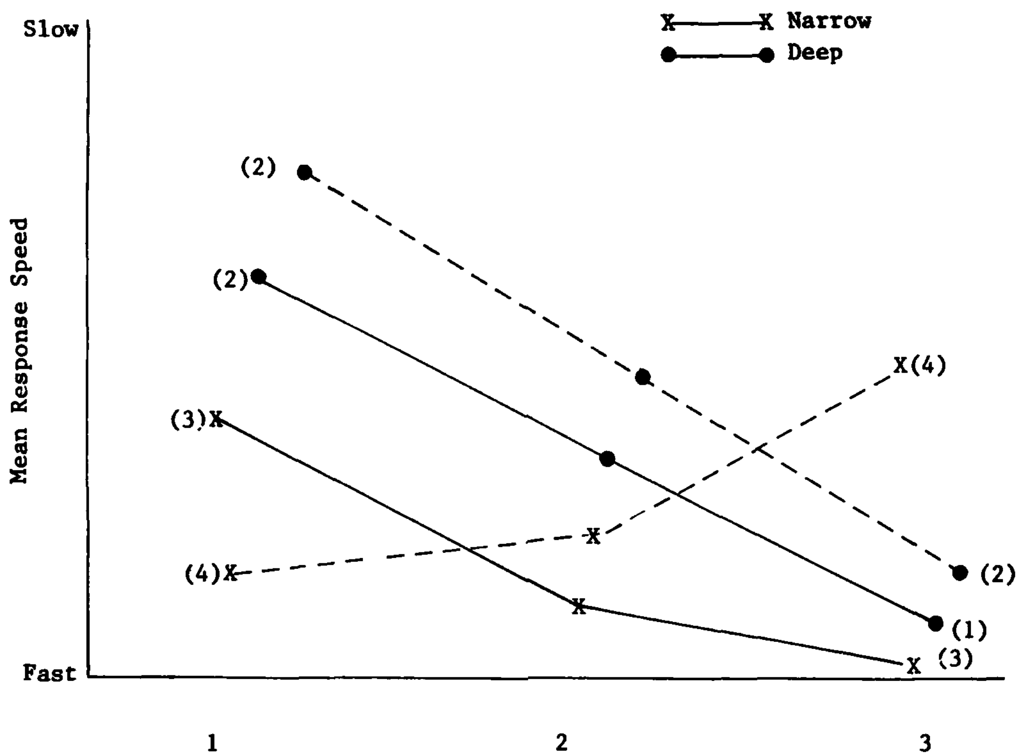


Figure 34.2 E. Changes in response speed given the interaction of desk width and layout.



Deep, male (1)
Deep, female (2)
Narrow, male (3)
Narrow, female (4)

Figure 34.3. Changes in response speed given the interaction of desk width and layout.

LESSON 35: REVIEW, OR HOW HAVE I DONE SO FAR?

This lesson presents a review of lessons 21-34. The remainder of this page is provided for any notes you may wish to jot down.

NOTES:

LESSON 36: HUMAN FACTORS AND THE MILITARY

This lesson reviews in detail the major military standards and specifications which have been referenced throughout the course.

OUTLINE

I. AR 602-1

II. MIL-STD-1472

III. MIL-HDBK-759

IV. MIL-STD-1474

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Human Engineering Program Plan	DOD	DI-H-7051

3. DESCRIPTION/PURPOSE The Human Engineering Program Plan is the single document which describes the contractor's entire human engineering program, identifies its elements and explains how the elements will be managed. This document is used by the procuring activity as the principal basis for approval of the contractor's program and as one basis for review of the contractor's progress.	4. APPROVAL DATE 1 June 1979 5. OFFICE OF PRIMARY RESPONSIBILITY ARMY/MIRADCOM 6. DDC REQUIRED 8. APPROVAL LIMITATION
7. APPLICATION/INTERRELATIONSHIP The Human Engineering Program Plan (HEPP) is related to DI-H-7053, Human Engineering Test Plan and DI-H-7052, Human Engineering Dynamic Simulation Plan. This DID replaces DI-H-1312A, DI-H-2104, DI-H-3259, UDI-AH-5014, UDI-R-20182, UDI-M-22272B and UDI-H-25568. This DID is primarily applicable to work tasks delineated in paragraph(s) 3.1.2 of MIL-H-46855B.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-H-46855B MIL-STD-1472 MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 General. The HEPP shall describe an integrated effort within the total project and shall contain specific information to show how and when the contractor shall satisfy all human engineering performance, design and program requirements specified in the contract.

10.2 Format and Content Requirements. The HEPP shall consist of the following sections:

(1) Table of Contents, List of Illustrations and Introduction.

(2) Tailoring. This section shall propose tailoring of MIL-H-46855B as specifically applicable to this contract, additional to any tailoring already accomplished by the procuring activity or where exceptions or other tailoring changes are warranted. This proposed tailoring of MIL-H-46855B shall identify specific provisions by paragraph, rationale for tailoring and effects of tailoring on the human engineering program. If no tailoring of MIL-H-46855B is proposed beyond that specified by the procuring activity, this shall be stated.

(3) Organization. This section shall identify and describe the contractor's primary organizational element responsible for complying with human engineering requirements. The functions and internal structure of this element shall be defined.

DD FORM 1 JUN 68 1664

PAGE 1 OF 4 PAGES

10. PREPARATION INSTRUCTIONS (continued)

Structural definition shall include the number of proposed personnel on an annual basis and summary job descriptions for each person. In addition, the relationships of this element to other organizational elements responsible for areas impacted by human engineering, such as those charged with equipment and software design, safety, training, test and evaluation, integrated logistic support and other engineering specialty programs (such as reliability, maintainability, survivability/vulnerability, and transportability) shall be fully explained. The authority delegated to each of the elements shall be stated in explaining the relationships. This section shall also describe the methods by which the contractor shall ensure that compatibility is continuously maintained between the design of system hardware and software (including support and training equipment), human performance requirements, personnel requirements and training requirements.

(4) Human Engineering in Subcontractor Efforts. If any work related to system components or software having human interface is to be performed under subcontract, the subcontractor's organizational element responsible for human engineering shall be described to the same extent as the prime contractor's human engineering organization is covered. A copy of the human engineering requirements proposed for inclusion in each of these subcontracts shall be provided. The method(s) by which the prime contractor monitors subcontractor compliance shall be fully described.

(5) Human Engineering in System Analysis. This section shall identify those human engineering efforts in system analysis (or, where contractually required, in system engineering), as described in MIL-H-46855B, which are contractually applicable and the organizational element(s) responsible for their performance. Human engineering participation in system mission analysis, determination of system functional requirements and capabilities, allocation of system functional requirements to human/hardware/software, development of system functional flows and performance of system effectiveness studies shall be fully described. Any data required from the procuring activity shall be described.

(6) Human Engineering in Equipment Detail Design. This section shall describe the human engineering effort in equipment detail design to ensure compliance with the applicable provisions of MIL-STD-1472 and other human engineering requirements specified by the contract. Human engineering participation in studies, tests, mock-up evaluations, dynamic simulation, detail drawing reviews, systems design reviews and system/equipment/component design and performance specification preparation and reviews shall be fully described. When DI-H-7052, Human Engineering Dynamic Simulation Plan is required by the contract, the description of human engineering participation in dynamic simulation may be brief. Finally, this section shall propose tailoring of MIL-STD-1472

10. PREPARATION INSTRUCTIONS (continued)

as specifically applicable to the contract, additional to any tailoring already accomplished by the procuring activity or where exceptions and other tailoring changes (additional to the self-tailoring nature of MIL-STD-1472) are warranted. This proposed tailoring of MIL-STD-1472 shall identify specific provisions, by paragraph, as applicable. If no tailoring of MIL-STD-1472 is proposed beyond that specified by the procuring activity, this shall be stated.

(7) Human Engineering in Equipment Procedure Development. This section shall describe the human engineering effort in equipment procedure development to ensure compliance with paragraph 3.2.2.5 of MIL-H-46855B. The methods shall be stated by which the contractor shall ensure that:

a) operator and maintainer functions and tasks are allocated, organized and sequenced for efficiency, safety and reliability; and,

b) the results of this effort are reflected in operational, technical and training publications and in training system design.

(8) Derivation of Personnel and Training Requirements. This section shall describe the methods by which the contractor shall ensure that operator and maintainer personnel and training requirements are based upon human performance requirements developed from system analysis data.

(9) Human Engineering in Test and Evalution. This section shall describe human engineering test and evaluation as an integrated effort within the contractor's total test and evaluation program and shall contain specific information to show how and when the contractor shall satisfy human engineering test and evaluation requirements of MIL-H-46855B. Design milestones shall be identified at which human engineering tests are to be performed to assess compatibility among human performance requirements, personnel aptitude and skill requirements, training requirements and equipment design aspects of personnel-equipment/software interfaces. Major test and demonstration objectives shall be identified and proposed test methods shall be described. This section shall also identify the human engineering personnel involved in test and evaluation, and a summary of the human engineering test schedule. The summary test schedule shall depict major human engineering tests, evaluations and demonstrations in relationship to major project milestones such as 90 percent design release, project level design reviews, first article demonstration tests and commencement of procuring activity testing. When DI-H-7053, Human Engineering Test Plan is required by the contract, this section may briefly summarize proposed T&E efforts.

10. PREPARATION INSTRUCTIONS (continued)

(10) Human Engineering Deliverable Data Products. This section shall identify and briefly describe each human engineering deliverable data product specified in the contract.

(11) Time-Phase Schedule and Level of Effort. This section consists of a milestone chart which identifies each separate human engineering effort to be accomplished and shall state the level of effort (in man-months) for each task.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Human Engineering Dynamic Simulation Plan	DOD	DI-H-7052
3. DESCRIPTION/PURPOSE This plan describes the contractor's intended use of dynamic simulation techniques in support of human engineering analysis, design support and test and evaluation.	4. APPROVAL DATE 1 June 1979	
	5. OFFICE OF PRIMARY RESPONSIBILITY ARMY/MIRADCOM	
	6. DDC REQUIRED	
	8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP This DID is related to DI-H-7059, Human Engineering Progress Report. This DID replaces UDI-H-21388. This DID is primarily applicable to work tasks delineated in paragraph(s) 3.2.2.1.2 of MIL-H-46855B.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-H-46855B	
	MCSL NUMBER(S)	

10. PREPARATION INSTRUCTIONS

10.1 Content Requirements. The plan shall consist of the following information:

1) Rationale and General Description. The need for a dynamic simluation program shall be described. The overall simulation concept shall be described. Benefits to be derived from dynamic simulation shall be stated. The interrelationships between dynamic simulation and other human engineering analysis, design support and test and evaluation techniques shall be described.

2) Techniques. Each dynamic simulation technique and procedure proposed by the contractor shall be fully described. Rationale for the selection of techniques shall be given. The specific contributions of each technique to human engineering anslysis, design support and test and evalution shall be stated. Previous efforts conducted by the contractor or others to validate each proposed technique shall be described, including a discussion of results.

3) Activities. The intended use of each dynamic simulation technique shall be described with regard to each of the following:

a) human performance and workload analysis, test and demonstration.

b) system design development, test and demonstration.

DD FORM 1 JUN 68 1664

PAGE 1 OF 2 PAGES

10. PREPARATION INSTRUCTIONS (continued)

c) system effectiveness studies, tactics development and verification

d) development and verification of operator skill, knowledge and other training data.

e) operator procedures development and verification, including degraded mode and emergency procedures.

f) training equipment design and verification studies

g) development and verification of technical publications

4) Organization and Personnel. The plan shall identify and describe the contractor organizational elements responsible for executing the Human Engineering Dynamic Simulation Plan. Structural definition shall include the number of proposed personnel, level of effort (in man-months) and the functions of key personnel. The relationships between responsible organizational elements shall be described. The authority delegated to each element shall be stated in explaining the relationship.

5) Schedule. A detailed schedule shall be prepared. Compatibility between the simulation schedule and the release of program analyses, design and test products for each area of utilization described in paragraph 3) above shall be described. Facility and special requirements (per paragraph (7) below) shall be indicated on the schedule.

6) Data. Data acquisition procedures and techniques, types of qualitative and quantitative data to be obtained and data analysis techniques shall be fully described. The plan shall state that simulation results shall be described in Human Engineering Progress Reports (DI-H-7059).

7) Facilities and Special Requirements. Dynamic simulation facilities shall be described. Any requirements to utilize government facilities, models, data or other government property shall be identified. If the contractor requires participation by government personnel (e.g., as subjects in simulation studies), appropriate information shall be provided - such as number and qualifications of personnel, desired level of participation and schedule of participation.

8) Scenarios and Mission Descriptions. The scenarios and missions to be simulated shall be described. Information on mission objectives, geography, threats, weather conditions, or any other data relevant to system simulation shall be presented.

10.2 <u>Format Requirements</u>. The Human Engineering Dynamic Simulation Plan shall be prepared in contractor format.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Human Engineering Test Plan	DOD	DI-H-7053

3. DESCRIPTION/PURPOSE This plan details the proposed testing to demonstrate that the personnel-equipment/software combination can accomplish the intended operation and maintenance functions in accordance with system specifications. This plan serves as the principal means of planning for validating human performance requirements, accuracy of personnel selection criteria, adequacy of training, and acceptability of design of the personnel-equipment/software interface.	4. APPROVAL DATE 1 June 1979 5. OFFICE OF PRIMARY RESPONSIBILITY ARMY/MIRADCOM 6. DDC REQUIRED 8. APPROVAL LIMITATION
7. APPLICATION/INTERRELATIONSHIP This DID is related to DI-H-7051, Human Engineering Program Plan, DI-H-7055, Critical Task Analysis Report and DI-H-7058, Human Engineering Test Report. This DID replaces DI-H-1313 and DI-H-2105. This DID is primarily applicable to work tasks delineated in paragraph(s) 3.2.3 of MIL-H-46855B.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-H-46855B MIL-STD-1472 MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 General. The Human Engineering Test Plan (HETP) shall document in detail the contractor's plan for gathering and analyzing data to show that the system, when fielded, will satisfy four criteria:

1) All human performance requirements for operations and maintenance can be performed to an acceptable level or standard under conditions of expected use;

2) the human performance requirements for operations and maintenance can be performed reliably by personnel reasonably representative of the military personnel who will ultimately perform them;

3) both the cost (in terms of all resources required) and some measure (based on human performance time and error data) of prospective effectiveness of the contractor's training program for operations and maintenance are known; and

4) the design of system hardware and software facilitates efficient, safe and accurate human performance.

10.2 Content Requirements.

1) Introductory information

DD FORM 1 JUN 68 1664

10. PREPARATION INSTRUCTIONS (continued)

a) Title descriptive of each test to be conducted.

b) Identification of equipment (or concept) being tested.

c) Statement of the task groups (or portions thereof) being reported. (A list, in sequential order, of all of the discrete performance tasks--with critical tasks identified--which will be required of each person in the system.)

d) Purpose of tests.

e) Objective(s) of tests (if different from subparagraph d) above).

2) Test Design. Identification of test conditions, performance measures, sample sizes, and sequence of test events.

3) Test Methods and Controls. Description of procedures to be followed in conducting each test. Explanation of how environmental variables and other factors which could affect the performance measures will be controlled or described, including where relevant:

a) noise

b) illumination level

c) shock and vibration

d) air temperature and humidity

e) ventilation

f) exposure to toxic or hazardous substances.

4) Test Participants. General description of the personnel population from which test participants will be selected. Identification and justification of test participant selection criteria. Identification of methods by which data describing actual test participants will be gathered, including, where relevant:

a) age

b) weight

c) sex

d) body dimensions relevant to performance tasks (paragraphs 3.1 and 5.6 of MIL-STD-1472)

e) visual acuity

10. PREPARATION INSTRUCTIONS (continued)

f) hearing level

g) existence of physical disabilities

h) educational and work experience

i) prior experience relevant to performance tasks

5) Training of Test Participants.

a) Description of type and amount (in hours) of system-specific pre-test training planned for test participants.

b) Description of any end-of-training comprehension test administered to test participants before test data-gathering begins.

6) Equipment Involved.

a) Description of mockup or equipment on which tests will be conducted (including material to be used and type of fabrication; dimensions; and cross-reference to blueprints, drawings or sketches).

b) Identification of other, non-system equipment involved in tests (including all equipment to be worn, carried or otherwise borne on the body of test participants such as weapon, communications equipment, headgear, survival equipment, protective mask and night vision equipment).

7) Data collection. Detailed description of the instrumentation or other means which will be used to obtain raw data on each of the performance measures. Identification of forms, if any, which will be used for recording data. Description of the frequency and means by which data on environmental variables and other extraneous factors will be collected.

8) Data Reduction. Detailed descriptions of techniques to be used for transformation and combination of raw data; statistical techniques to be employed and assumptions pertaining to the use of each (e.g., normally distributed); and confidence levels selected.

9) Data Analysis. Explanation of how the data collected will be used in:

a) human performance error analysis (e.g., "calculating operator error rate for mission-critical tasks")

b) identifying incompatibilities among human performance and equipment

10. PREPARATION INSTRUCTIONS (continued)

c) system safety analysis

d) logistics and maintainability assessment(s).

e) calculating system reliability, availability and effectiveness.

10) Test Reporting. Identification of tests for which a Human Engineering Test Report (DI-H-7058) will be prepared and tentative date(s) of initial submission.

10.3 Completeness.

This plan, if submitted incrementally to facilitate use of previous test results in planning additional tests which may be necessary, shall not be considered complete until all task groups and mission segments and their interactions have been accounted for.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S). AGENCY	NUMBER
1. TITLE Human Engineering System Analysis Report	DOD	DI-H-7054
3. DESCRIPTION/PURPOSE This report describes the human engineering efforts conducted as part of system analysis and presents results. The data are used by the procuring activity to evaluate the appropriateness and feasibility of system functions and roles allocated to operators and maintainers.	4. APPROVAL DATE 1 June 1979 5. OFFICE OF PRIMARY RESPONSIBILITY ARMY/MIRADCOM 6. DDC REQUIRED 8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP This DID replaces UDI-H-21386 and UDI-H-21387. This DID is primarily applicable to work tasks delineated in paragraph(s) 3.2.1 through 3.2.1.2 of MIL-H-46855B.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-H-46855B MCSL NUMBER(S)	

10. PREPARATION INSTRUCTIONS

10.1 General. The Human Engineering System Analysis Report (HESAR) shall be prepared which describes human engineering analyses of system functions, system information flow and processing requirements and operator/maintainer capabilities which are conducted to determine plausible human roles.

10.2 Content Requirements. The HESAR shall consist of the following information:

1) System Objective(s). In accordance with information provided by the procuring activity and/or contractor studies, the system objective(s) shall be described. If the objective(s) are to be met by the system operating in conjunction with other systems not within the scope of the contract, the following shall also be described:

a) The overall (or higher level) objective(s) to be met through combined operation of systems

b) The sub-objective(s) to be met by the system being developed under the contract

c) interactions required between systems to meet the overall objective(s).

2) System Mission(s). In accordance with information provided by the pro-

DD FORM 1 JUN 68 1664

PAGE 1 OF 2 PAGES

10. PREPARATION INSTRUCTIONS (continued)

curing activity and/or based upon contractor studies, the system mission(s) shall be described. The mission description(s) shall describe the context(s) within which the system will meet its objective(s); e.g., geography, mission time constraints, weather, day/night, humidity, sea state, terrain roughness, vegetation density, enemy force concentration, enemy weapons/countermeasures capabilities, enemy order of battle, presence/absence of other cooperating systems, etc.

3) System Functions. In accordance with information provided by the procuring activity and/or based on contractor studies, the system functions (which must be performed to meet the system objective(s) within the mission context(s)) shall be described.

4) Allocation of System Functions. Analyses conducted in accordance with paragraph 3.2.1.1 of MIL-H-46855B shall be described. Specifically, the following analyses and the results of these analyses shall be presented:

a) Information Flow and Processing (paragraph 3.2.1.1.1 of MIL-H-46855B)

b) Estimates of Potential Operator/Maintainer Processing Capabilities (paragraph 3.2.1.1.2 of MIL-H-46855B)

c) Allocation of Functions (paragraph 3.2.1.1.3 of MIL-H-46855B)

5) Equipment Identification. In accordance with information provided by the procuring activity and based upon contractor studies conducted in accordance with paragraph 3.2.1.2 of MIL-H-46855B, the selected design configuration shall be described.

10.3 Format Requirements. The HESAR shall be prepared in contractor format.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Critical Task Analysis Report	DOD	DI-H-7055

3. DESCRIPTION/PURPOSE

This report describes the results of critical task analyses performed by the contractor to provide a basis for evaluation of the design of the system, equipment or facilities. The evaluation will verify that human engineering technical risks have been minimized and that solutions are in hand.

4. APPROVAL DATE

1 June 1979

5. OFFICE OF PRIMARY RESPONSIBILITY

ARMY/MIRADCOM

6. DDC REQUIRED

8. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP

This DID replaces DI-H-2109 and DI-H-7012.

This DID is primarily applicable to a portion of the work tasks delineated in paragraph(s) 3.2.1.3.1 and 3.2.1.3.2 of MIL-H-46855B.

9. REFERENCES (MANDATORY AS CITED IN BLOCK 10)

MIL-H-46855B

MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 This report shall describe and analyze each critical task, including:

1) Information required by/available to personnel which is relevant to the critical task assigned to them.

2) Actions which each performer must complete to accomplish the critical task, including responses to specific information, responses to combinations of information, and self-initiated responses.

3) The functional consequences of each operator or maintainer critical task with respect to the effects upon both the immediate subsystem functions and the overall system mission.

10.2 The report shall also include, for each critical task, the factors described by paragraph 3.2.1.3.2 (1) through (20) of MIL-H-46855B.

10.3 The task analysis information shall be presented in one or more of the following formats, as appropriate. However, the same information shall not be presented twice, regardless of form.

1) Flow Diagrams. Used primarily to describe the sequential, parallel or interactive relationships of human tasks and equipment actions showing the relevant

DD FORM 1 JUN 68 1664

PAGE 1 OF 2 PAGES

10. PREPARATION INSTRUCTIONS (continued)

antecedents and the consequences of each operator action.

2) Tabular Presentation. Used to describe discrete units of a given task measured along a time-base or other quantitative performance criteria. This mode of presentation may be used to show a level of detail that cannot be encompassed in the flow diagrams.

3) Narrative Description. Used to describe tasks which can be satisfactorily accomplished by any of a number of optional procedures which may be chosen by the operator. Such description shall specify the concepts and objectives of the task to be performed rather than the concrete procedures to be employed.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S). AGENCY	NUMBER
1. TITLE Human Engineering Design Approach Document-Operator	DOD	DI-H-7056

3. DESCRIPTION/PURPOSE

This document provides a source of data to evaluate the extent to which equipment having an interface with operators meets human performance requirements and human engineering criteria.

4. APPROVAL DATE

1 June 1979

5. OFFICE OF PRIMARY RESPONSIBILITY

ARMY/MIRADCOM

6. DDC REQUIRED

8. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP

This DID replaces DI-H-2107, DI-H-3261A, DI-H-4605, UDI-H-21272 and UDI-H-21385.

This DID is primarily applicable to work tasks delineated in paragraph(s) 3.2.1.2, 3.2.1.3, 3.2.1.4, and 3.2.2 of MIL-H-46855B.

9. REFERENCES (MANDATORY AS CITED IN BLOCK 10)

MIL-H-46855B
MIL-STD-1472

MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 General. The Human Engineering Design Approach Document - Operator (HEDAD-O) shall be prepared which describes the layout, detail design and arrangement of crew station equipment having an operator interface; it shall also describe operator tasks associated with the equipment. The HEDAD-O shall describe the extent to which the human performance requirements, MIL-STD-1472 and other applicable human engineering documents specified in the contract have been incorporated into the layout, design and arrangement of equipment having an operator interface. Operator task analysis results shall be presented as part of the rationale supporting the layout, design and integration of crew station equipment.

10.2 Content Requirements. HEDAD-O shall consist of the following crew station and operator-related information:

1) List of each item of equipment having an operator interface and a brief statement of the purpose of each item of equipment. Separate lists shall be provided for each operator's station.

2) List of specifications and drawings approved by human engineering at the time of HEDAD-O preparation. When contractually required to prepare and submit the HEDAD-O early in the development process, the list shall also address documents where human engineering approval is planned.

DD FORM 1 JUN 68 1664

PAGE 1 OF 3 PAGES

10. PREPARATION INSTRUCTIONS (continued)

3) Description of the crew station(s), emphasizing human engineering design features. The following aspects of the (each) crew station shall be described:

a) Layout and Arrangement. One sketch, drawing or photograph of the (each) crew station shall be provided. These sketches, drawings or photographs shall contain operator and equipment-related reference points (e.g., operator eye position, seat reference point) and scale. One sketch, drawing or photograph of each item of crew station equipment shall be provided; the point of reference shall be normal to the item of equipment and scale shall be indicated.

b) Controls and Displays. The layout and detail design of each control/display panel (or control/display areas independent of panels) shall be described (e.g., phospher type, brightness, resolution, contrast, color or other coding, control/display ratio, control force and range characteristics). Display symbology, display formats and control/display operation logic shall be described with regard to intended use by the operator(s).

c) Operator Vision. Operator vision to crew station items of equipment shall be described using the operator's normal eye position(s) as the point of reference. When applicable, operator external vision shall also be described using the operator's normal eye position(s) as the point of reference; extent of external vision shall be related to system mission requirements.

d) Environmental Factors. Operator life support systems, protective clothing and equipment, noise, vibration, radiation, temperature, ambient illumination, climatic effects and other relevant environmental parameters shall be described.

e) Ingress/Egress. Normal and emergency ingress and egress provisions/procedures shall be described.

f) Crew Station Lighting. Lighting characteristics and lighting control systems shall be described.

g) Crew Station Signals. Warning, caution and advisory signals shall be described with regard to signal characteristics, signal meaning, signal consequences, operator procedures, cause of signal activation and crew control over signal characteristics.

h) Operator Posture Control. Seating, restraint systems and other postural control techniques shall be described.

i) Communications Systems and Communications Systems Control.

j) Special design, layout or arrangement features if required by mission or system environment.

10. PREPARATION INSTRUCTIONS (contined)

k) Multiple operator stations design, if applicable. Rationale for number of operators, arrangement of operators and allocation of functions to the operators shall be described.

4) Geometric layout of the crew station(s). Crew station geometry shall be described using the seat reference point or operator's eye position(s) as a reference point. The position of each control, display, panel, etc., shall be described in terms of three-dimensional space (X, Y, Z coordinates); operator eye position shall be described in terms of system design coordinates or as zero (X), zero (Y) and zero (Z). The center of each panel, display, control, etc., shall be used as the equipment point of reference. True angle to vision to each item of equipment shall also be shown.

5) Rationale for human engineering design, layout and arrangement of each item of crew station equipment having an operator interface. The specific considerations of system mission (or system function); equipment operation; operator selection, training and skill requirements; operator task performance requirements; and limitations imposed on designs by the procuring activity or state-of-the-art shall be described. The basis for reaching specific design, layout and arrangement decisions shall be presented (e.g., MIL-STD-1472 criteria, other human engineering requirements specified in the contract, system engineering analyses, systems analyses, human engineering studies, trade-off analyses, mock-up results, simulation results and human engineering test results).

6) Operator task analysis (see paragraph 6.2.5 of MIL-H-46855B) results shall be presented as part of the rationale for crew station design, integration and layout. The following shall also be described: methodology used to generate task analysis results (e.g., paper and pencil, computer-based simulation, dynamic simulation); system mission(s), function(s) or other exogenous information used to "drive" the task analysis; human performance data (i.e., time and error) against which task analysis results are compared; and operator assumptions (e.g., level of skill, training). Critical tasks (see paragraph 6.2.1 of MIL-H-46855B) shall be clearly identified.

7) Narrative which provides rationale for any need to deviate from, or take exception to, MIL-STD-1472 or other contractual human engineering documents.

8) Sketches, drawings or photographs of each item of equipment being considered as alternatives or changes to the selected (baseline) crew station design.

9) Design, arrangement or layout changes made since the last HEDAD-O preparation shall be described.

10.3 Format Requirements. Contractor format shall be utilized.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S). AGENCY	NUMBER
1. TITLE Human Engineering Design Approach Document-Maintainer	DOD	DI-H-7057

3. DESCRIPTION/PURPOSE This document provides a source of data to evaluate the extent to which equipment having an interface with maintainers meets human performance requirements and human engineering design criteria.	4. APPROVAL DATE 1 June 1979 5. OFFICE OF PRIMARY RESPONSIBILITY ARMY/MIRADCOM 6. DDC REQUIRED 8. APPROVAL LIMITATION
7. APPLICATION/INTERRELATIONSHIP This DID replaces DI-H-2108 and UDI-H-21385. This DID is primarily applicable to work tasks delineated in paragraph(s) 3.2.1.2, 3.2.1.3, 3.2.1.4, and 3.2.2 of MIL-H-46855B.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-H-46855B MIL-STD-1472 MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 General. The Human Engineering Design Approach Document - Maintainer (HEDAD-M) shall be prepared which describes the characteristics, layout, and installation of all equipment having a maintainer interface (excluding depot level maintenance actions); it shall also describe maintainer tasks associated with the equipment. The HEDAD-M shall describe the extent to which the requirements of MIL-STD-1472 and other applicable human engineering documents specified in the contract have been incorporated into the design, layout, and installation of equipment having a maintainer interface. Maintainer task analysis results shall be presented as part of the rationale supporting the layout, design and installation of the equipment. The requirement for this information is predicated on the assumption that, as analytic and study information, it is developed sufficiently early to influence the formulation of other system data such as maintenance allocation charts, special repair parts/tool lists, LSAR data. If the program has progressed to the point where the required data is available through other reporting media, such as those noted above, they shall not be duplicated but shall be referenced or appended to the HEDAD-M along with appropriate supplementary information fulfilling the intent of this provision.

10.2 Content Requirements. The HEDAD-M shall consist of the following information:

1) List of each item of equipment having a maintainer interface at the Organizational and Field/Intermediate Maintenance Activity (IMA) level, a brief statement

DD FORM 1 JUN 68 1664

10. PREPARATION INSTRUCTIONS (continued)

of the purpose of each item of equipment and the types of maintenance required on each item of equipment (e.g., troubleshoot, remove, inspect, test, repair).

2) List of specifications and drawings approved by human engineering at the time of HEDAD-M preparation. The list shall also address documents where human engineering approval is planned.

3) Description of system equipment, emphasizing human engineering design features. The following aspects of equipment shall be described:

a) Layout of System Equipment. (1) The location and layout of all system equipment requiring maintenance shall be described with emphasis on human engineering features which facilitate maintenance. Equipment located in areas assessed through common doors, panels, openings, etc., shall be indicated. (2) The location of each item of equipment shall also be noted in terms of three-dimensional space (i.e., X, Y, and Z coordinates); the reference point for each item of equipment shall be its center as viewed by the maintainer while gaining access to the equipment.

b) Design of Equipment. The design of each item of equipment shall be described with emphasis on human engineering features which facilitate maintenance such as handles, self-test capability, labeling, connector spacing and keying.

c) Installation of Equipment. The installation of each item of equipment shall be described with emphasis on human engineering features which facilitate maintenance such as fasteners, clearances, relationship between accessibility and failure rate (or scheduled maintenance frequency) of each item of equipment and visual access afforded.

4) Rationale. The specific considerations of equipment maintenance requirements (e.g., frequency, criticality, equipment failure rate), maintainer requirements (e.g., personnel selection, training and skills), maintainer task requirements, environmental considerations, safety and limitations imposed by the procuring activity or state-of-the-art shall be described. The bases for reaching specific design, layout and installation decisions shall be presented (e.g., MIL-STD-1472 criteria, other human engineering requirements specified in the contract, human engineering studies, trade-off analyses, mock-up results and human engineering test results).

5) List of special tools, support equipment, job aids/devices required for maintenance of each item of equipment.

6) Maintainer task analysis results presented as part of the rationale supporting layout, design, and installation of item of equipment. Maintainer task analyses shall consist of the following:

10. PREPARATION INSTRUCTIONS (continued)

task number, task title, task frequency (for scheduled maintenance actions) or estimated task frequency (based on equipment mean-time-between-failure for unscheduled maintenance actions), data source used (e.g., drawing number, sketch number, development hardware, actual production equipment), detailed task sequence (see paragraph 6.2.5 of MIL-H-46855B), support equipment required, tools required, job aids required, estimated task time, estimated personnel requirements (e.g., number of personnel required, skills and knowledge required) and human engineering considerations which reflect specific human engineering requirements incorporated into the design (e.g., maintainer fatigue, potential hazards, safety or protective clothing/equipment required or recommended, access problems, maintainer communication requirements, special task sequence requirements, labeling). As applicable, the following types of maintainer tasks shall be addressed by task analyses: remove/replace, trouble-shoot (fault location), repair, adjust, inspect, service and test. Critical tasks (see paragraph 6.2.1 of MIL-H-46855B) shall be clearly identified.

7) Narrative which provides rationale for any need to deviate from, or take exception to, MIL-STD-1472 or other contractual item human engineering requirements.

8) Two sketches, drawings or photograph of each of equipment having a maintainer interface. Each item of equipment shall be depicted, a) by itself from top, front and side (three-view trimetric or exploded trimetric view) and b) installed as the maintainer would normally view it during maintenance.

9) Sketches, drawings or photograph of each item of equipment being considered as alternatives to the selected, or baseline design. Sketches, drawings or photographs of alternative equipment installations or layouts which exist at the time of HEDAD-M preparation.

10) Description of design, installation or layout changes which have been made since the last HEDAD-M submission.

10.3 Format and Data Organization Requirements. The HEDAD-M be prepared in contractor format except that information shall be presented in two major parts:

1) Information pertaining to maintenance actions performed at the Organizational Level.

2) Information pertaining to maintenance actions performed at the Field/IMA level.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Human Engineering Test Report	DOD	DI-H-7058

3. DESCRIPTION/PURPOSE

This report provides evidence that the personnel-equipment/software interface requirements for the operation, maintenance and support of the system have been met. This report serves as the principal means of assessing the compatibility of the human performance requirements, personnel selection criteria, training program and design of the personnel-equipment/software interfaces.

4. APPROVAL DATE 1 June 1979

5. OFFICE OF PRIMARY RESPONSIBILITY ARMY/MIRADCOM

6. DDC REQUIRED

8. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP

This DID is related to DI-H-7051, Human Engineering Program Plan, DI-H-7053, Human Engineering Test Plan, and DI-H-7055, Critical Task Analysis Report.

This DID replaces DI-H-1334A and DI-H-2111.

This DID is primarily applicable to work tasks delineated in paragraph(s) 3.2.2.4 and 3.2.3 of MIL-H-46855B.

9. REFERENCES (MANDATORY AS CITED IN BLOCK 10)

MIL-H-46855B
MIL-STD-1472

MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 General. A Human Engineering Test Report (HETR) shall be prepared by the contractor for each personnel position in the system being developed. All of the operations and maintenance tasks required of the individual assigned to a personnel position are referred to as the "task group" of that position.

10.2 Content Requirements.

1) Introductory Information

a) Specific title of test

b) Identification of equipment or concept being tested

c) Specific purpose of this test

d) Objectives of this test (if appropriate, stated in terms of hypotheses to be tested)

e) Date(s), location(s), and name(s) of individual(s) present and supervising the conduct of the test.

DD FORM 1 JUN 68 1664

BLOCK 3, DESCRIPTION/PURPOSE (Continued)

This report will be used to determine whether and to what level or standard(s) each trained individual can perform in the specified sequence all assigned systems tasks; to determine whether and to what extent each individual's performance is affected by equipment configuration, the performance of other system personnel, or both; and to assess the impact of the measured human performance on the attainment of task, task group, and mission requirements.

BLOCK 10, PREPARATION INSTRUCTIONS (Continued)

f) for each task group or portion thereof reported, a list of all the discrete tasks and a brief description of the operational environment in which they are to be performed when the system is deployed.

2) Description of Test Methods and Controls

a) Statement of (or reference to) any human performance standards (e.g., "0.9 probability of operator launching missile within 10 seconds after detecting target") or assumed contribution to error (e.g., "aiming error less than 3 mils") contained in system development documents. If none, so state.

b) Description of environment at each distinct location of human performance. (Include noise and illumination levels, shock and vibration, air temperature and humidity, and ventilation. Also, state the concentration of and test participant exposure time to any toxic or hazardous substances; and state whether that exposure was or was not within the applicable safety limits for each substance.)

c) Description of test participants. For each participant, where relevant, state age, weight, body dimensions applicable to performance tasks (see paragraphs 3.1 and 5.6, MIL-STD-1472), visual acuity and hearing levels, any known physical disabilities, and educational and work experience.

d) Description of individual clothing and equipment (including all clothing and equipment worn, carried or otherwise borne on the body, such as weapon, communications equipment, headgear and protective mask).

e) Type and amount (in hours) of system-specific pre-test training (differentiating "hands on" practice from other training) given to test participants; and type, content and results of training assessment used. Also, state time intervals between end of training, training assessment and start of tests being reported.

10. PREPARATION INSTRUCTIONS (continued)

f) Description of mockup or equipment on which test is conducted (including material used and type of fabrication; dimensions; and cross-reference to blueprints, drawings or sketches).

g) Identification of deviation(s) during the test from conditions of expected use (subparagraph 1b(1)(f) above); narrative explanation of reason(s) for deviation(s), and presumed effect(s) of such deviation(s) on the validity of generalizations from test data.

3) Data Collection Techniques

a) Identification of the quantitative and qualitative measures of both human and system performance.

b) Description of methods, procedures and instrumentation used in data collection.

c) Description of techniques used for data reduction, statistical techniques employed, and confidence levels selected.

4) Results

a) Summaries of quantitative human and system performance data.

b) Summaries of qualitative data (including questionnaires, interviews, checklists, etc.).

5) Description of Human Performance Errors

a) Narrative description, with photograph(s) if appropriate, of each error. Include frequency of occurrence of each error during test.

b) Consequence (brief statement of the immediate effect of the error on system operation).

c) Causes (isolation of the immediate cause of each actual performance error and identification of the events, conditions, operator workload, environmental factors and equipment configurations which may have contributed to it).

d) Explanation by participants making errors of the reasons for the errors.

e) Recommended solutions (stated in terms of equipment redesign, alteration of tasks, personnel selection and/or training). Provide rationale.

10. PREPARATION INSTRUCTIONS (continued)

6) Description of Incompatibilities Among Human Performance and Equipment.

a) Identification

1. During the test what tasks of one task group interfered with the performance of which tasks of another task group? If none, so state.

2. During the test what human performance was adversely affected by what equipment configurations or characteristics? (Identify controls and/or displays needed but not present). If none, so state.

b) Recommended solutions (stated in terms of equipment redesign, alteration of tasks, personnel selection and/or training). Provide rationale.

7) Description of Observed Safety Hazards.

a) Narrative description, with photograph(s) if appropriate, of each safety hazard identified during the test. If none, so state.

b) Frequency each hazard was encountered by test participants.

c) Severity and consequence of each hazard.

d) Recommended action to eliminate or minimize hazard (stated in terms of equipment redesign, alteration of tasks, personnel selection and/or training). Provide rationale.

8) Analysis of Impact of Human Performance on Attainment of System Performance Goals.

a) Statement of (or reference to) system performance goals.

b) Narrative explanation of reasons why any human performance tasks required by present equipment design are not feasible; or why any standards presently set for specific human performance tasks are unattainable. (If all human performance requirements are feasible and any standards set appear to have been met, so state).

c) Narrative explanation of how measured human performance times and errors in operations and maintenance can affect system reliability and availability.

d) Narrative explanation of how measured human performance times and error frequencies and magnitudes can affect system effectiveness.

10. PREPARATION INSTRUCTIONS (continued)

e) Narrative explanation of how system performance goals would be affected by implementing the solutions recommended in subparagraphs (5), (6) and (7) above.

9) Conclusions

a) Summary of major findings from test.

b) Implications of major findings (including anticipated effects on system reliability, availability and effectiveness).

10) List of recommended changes to equipment configuration, human performance tasks, personnel selection and/or training (in order of decreasing importance) with indication of government or contractor organizations responsible for implementing recommended actions.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Human Engineering Progress Report	DOD	DI-H-7059

3. DESCRIPTION/PURPOSE This report describes status of the contractor's human engineering program. Each report is used to transmit human engineering progress, problems, and plans for each succeeding reporting period. These reports provide evidence that human engineering considerations are reflected in system design and development and indicate compliance with contractual requirements for human engineering.	4. APPROVAL DATE 1 June 1979 5. OFFICE OF PRIMARY RESPONSIBILITY ARMY/MIRADCOM 6. DDC REQUIRED 8. APPROVAL LIMITATION
7. APPLICATION/INTERRELATIONSHIP This DID replaces DI-H-1314 and DI-H-2110. This DID is primarily applicable to work tasks delineated in paragraph(s) 1.1, 3.1.2, and 3.3 of MIL-H-46855B.	9. REFERENCES (MANDATORY AS CITED IN BLOCK 10) MIL-H-46855B MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 General. The Human Engineering Progress Report shall describe progress and activity in sufficient detail to demonstrate that human engineering considerations are reflected in systems analyses (or systems engineering analyses where required), system design and development, and system test and evaluation. Progress reports shall be concise and shall not unnecessarily repeat previously reported material. Changes may be indicated by reference to past reports rather than by duplication of an entire set of data, information or plans. Where detailed data are furnished by other reporting media, they shall be referenced by, rather than included in, the progress report; however, general summary information, reflecting results of efforts germane to reported progress, shall be included.

10.2 Content Requirements. The following information shall be presented:

1) Summary and current status of all human engineering activity.

2) Summary and status of all human engineering design recommendations and action items.

3) Summary of human engineering participation in design reviews and program reviews.

DD FORM 1 JUN 68 1664

PAGE 1 OF 2 PAGES

10. PREPARATION INSTRUCTIONS (continued)

4) Summary results of human engineering analyses, studies, experiments, mock-up evaluations, simulation activities, tests and demonstrations.

5) Results of projects which involved human engineering participation (e.g., trade-off studies). Other documentation reflecting changes to system design which affect man-machine interface shall be appended to the report as needed.

6) Deviations from the Human Engineering Program Plan (DI-H-7051) currently being requested.

10.3 Format Requirements. Human Engineering Progress Reports shall be prepared in contractor format except that separate sections shall address each of the following areas:

1) Work accomplished this reporting period. This section shall address tasks begun, completed or in progress; significant results of completed tasks; end item products completed and available for review; unusual conclusions that may portend modification to future activities.

2) Work planned for next reporting period. This section shall address tasks that will be commenced or completed.

3) Problems. This section shall identify specific problems which occurred during the reporting period or are anticipated to occur during the next reporting period. Effects of problems on other tasks, schedules, costs or program scope shall be indicated. Proposed solutions shall be presented.

4) Actions required of the procuring activity. This section shall identify special requirements or problems wherein procuring activity assistance is or may be required.

5) Appendix. This section shall present reports, project notes, drawings or other documentation required to ensure completeness of the progress report.

LESSON 37: HUMAN FACTORS TEST AND EVALUATION, OR CAN A HEFTYMAN CROSS A MOAT USING A HEDGE?

Lesson 37 discusses the area of human factors testing problems and identifies some human performance data. In addition, military documentation used in this area is presented.

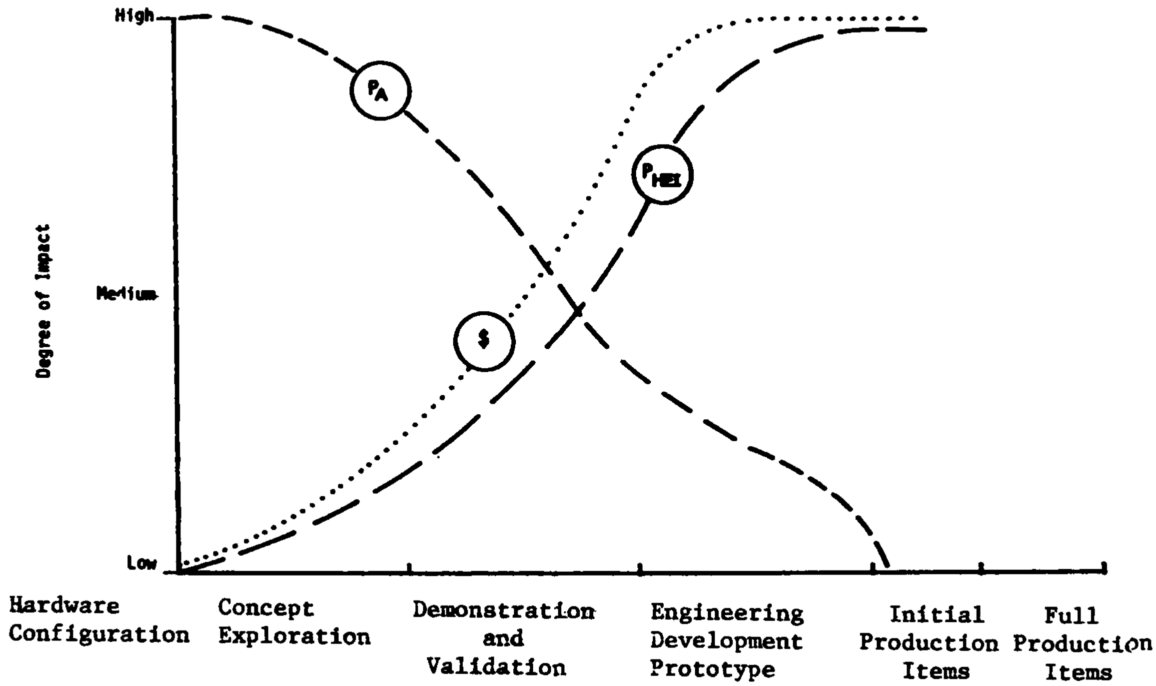
OUTLINE

I. HF Testing

   A. HEL TM 29-76
   B. MOAT
   C. HFTEMAN
   D. HEDGE
   E. HRTES

II. Human Performance Measures

   A. Analysis of human performance data



P_A: Probability of Acceptance of A Human Engineering Design Change Proposal

$: Cost of Proposed HFE Change

P_{HEI}: Probability of Being Able to Propose A Human Engineering Improvement

Figure 37.1. Relationships among P_{HEI}, P_A, and cost (from TM 29-76.)

LESSON 38: REAL WORLD PROBLEM, PART I

This lesson reviews the material presented in the course in order to point out to the student any deficiencies in knowledge as well as to build confidence in his/her ability.

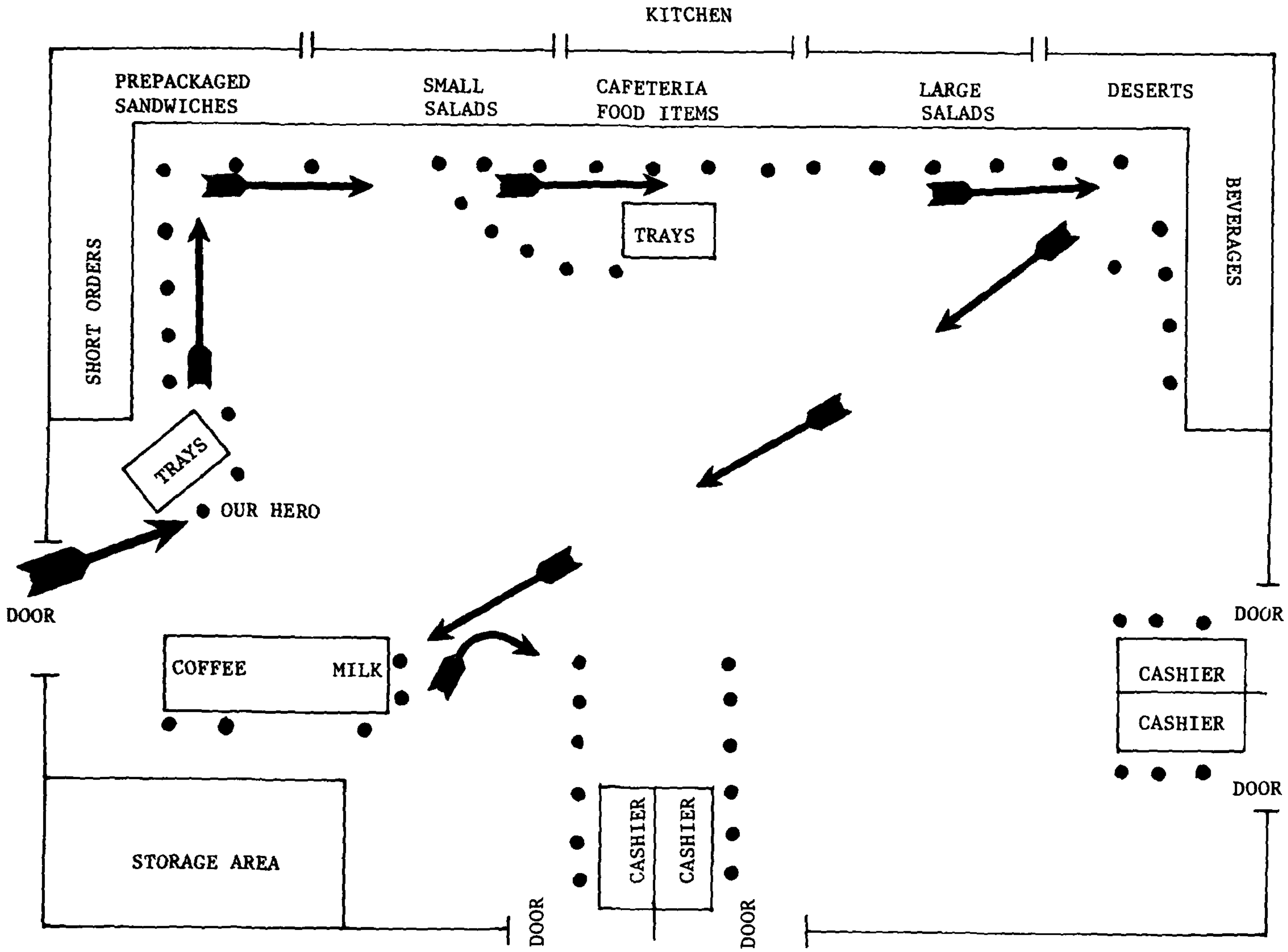


Figure 38.1. Cafeteria customer traffic flow. Arrow repesents path of one customer. Darkened circles represent other customers. See lesson 38 for explanation.

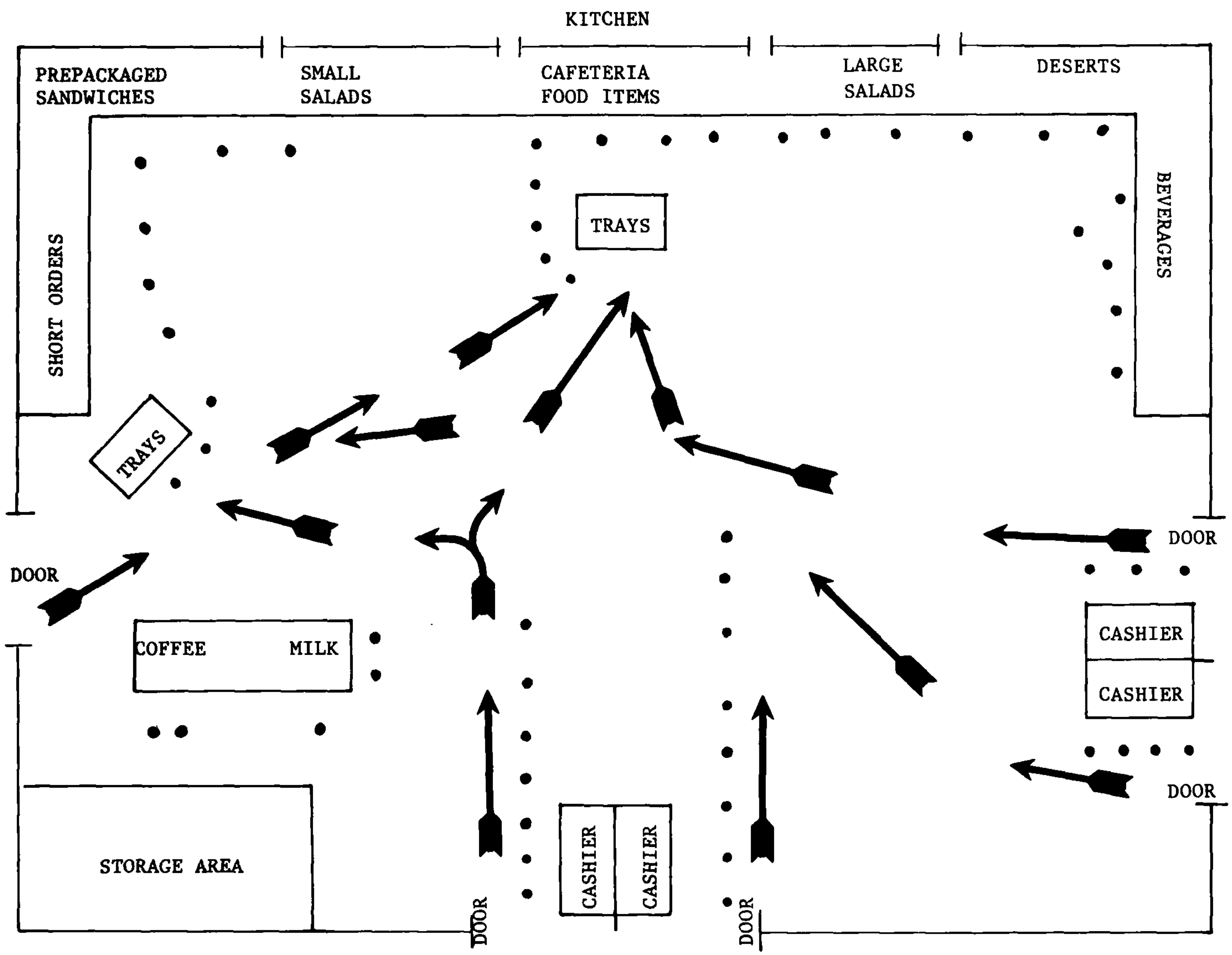


Figure 38.2. Variety of possible entry paths a cafeteria customer could take.

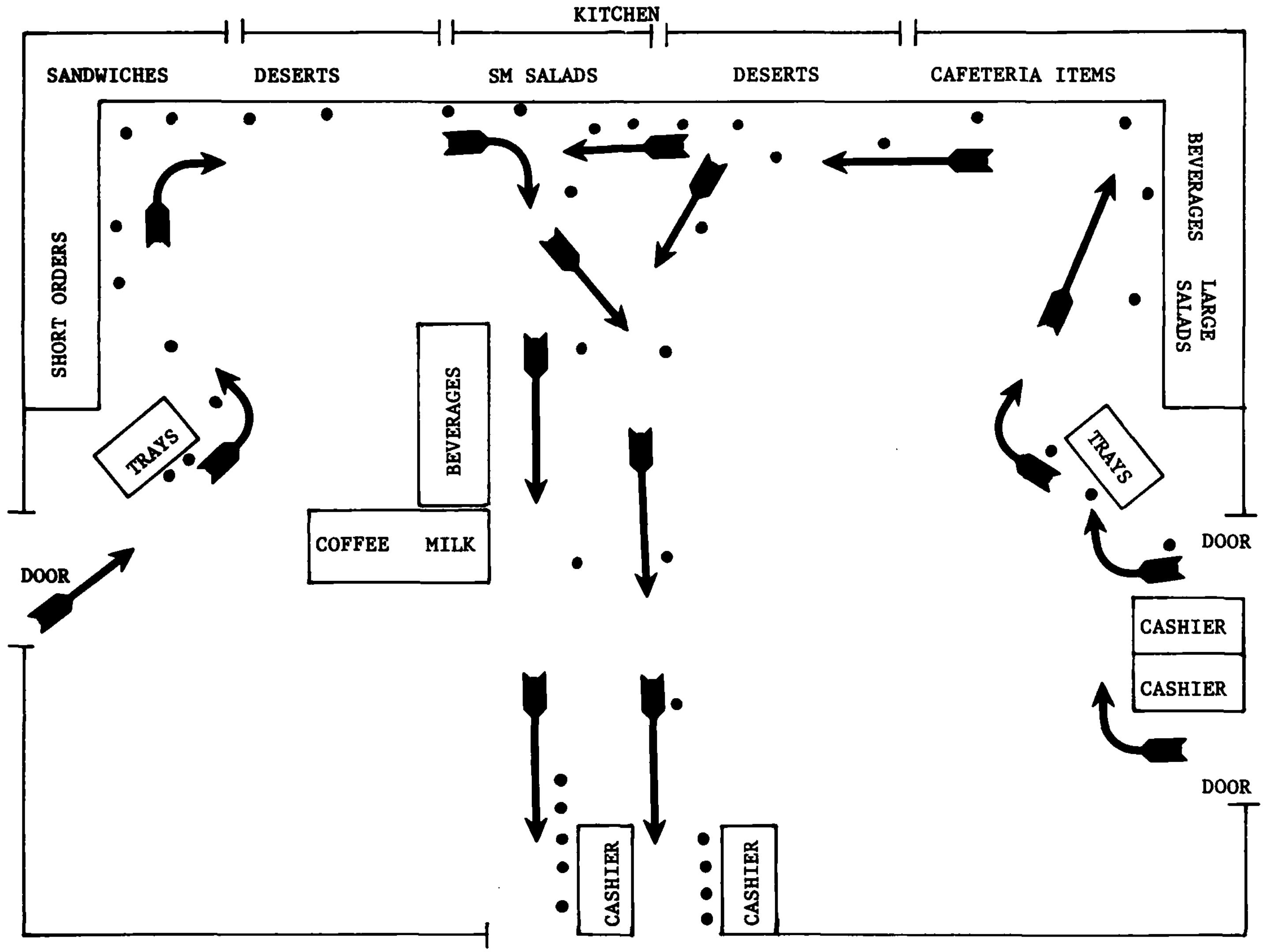


Figure 38.3. Existing traffic flow in problem cafeteria.

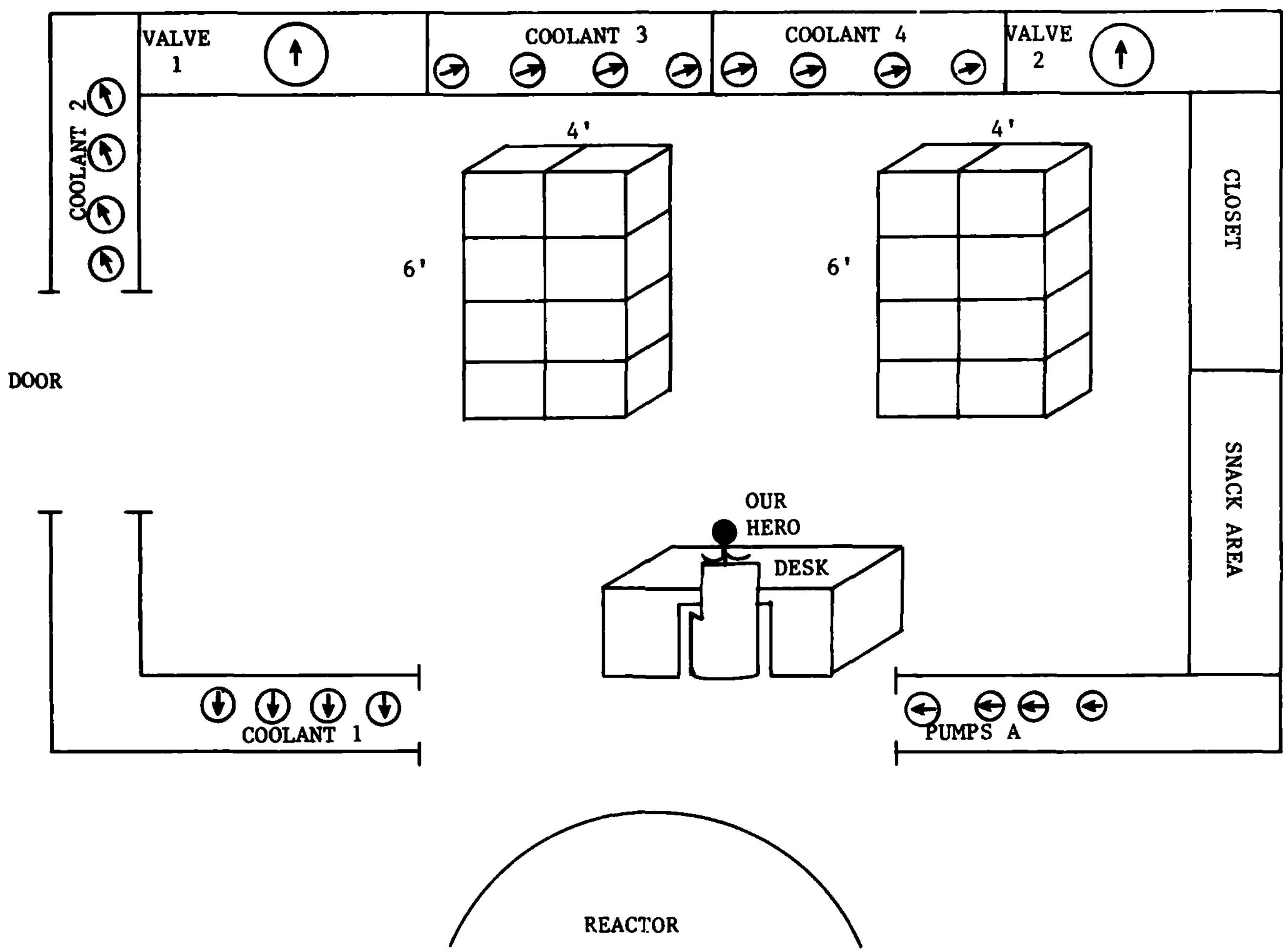


Figure 38.4. Nuclear Reactor Control Room. See next page for information to use with this figure.

INSTRUCTIONS FOR FIGURE 38.4

Well, here we are with a practical problem for you to solve on your own. As you can see, our hero is seated at his desk in the control room of a nuclear reactor. At this time his sole task is to complete a checkoff of the displays presented in figure 38.4. All displays of similar functions should have the same reading if the system is to be considered safe. Here is the checkoff sequence our hero must use:

1. Pumps A
2. Coolants 1, 2, 3, 4
3. Valves 1, 2

Your problem is to see if you can arrange the room so this sequence can be completed in a more efficient and effective manner. Play with the arrangement before looking at the helpful hints.

HELPFUL HINTS

1. Are displays arranged in checkoff order?
2. Do files interfere with vision-display interface?
3. Is coolant 1 supposed to be behind the operator!?!
4. Did you notice that coolant 1 readings are different from those of coolants 2-4? How can you arrange them so that this would be more effective?

LESSON 39: REAL WORLD PROBLEM, PART II

This lesson reviews the material presented in the course to point out to the student any deficiencies in knowledge as well as to build confidence in his/her ability.

NOTES:

LESSON 40: OVERALL SUMMARY

This lesson reviews the various concepts and terms presented in the previous lessons. The student will be required to integrate various key concepts to which he has been exposed.

NOTES:

CHECKLIST FOR CONTROL DESIGN

1. Have you chosen the best type of control? The broad types discussed were continuous adjustment and discrete setting. The advantages and disadvantages of these broad categories, as well as some of the more specific types, are presented in table 11.1 in this supplement.

2. Is the control the right size? Can the operator find it? Does it allow for adequate movement?

3. Are the operating force, extent of movement, and speed of movement correct? How much pressure is required to operate the given control? Have you selected the right body part to activate or operate this control? Is there enough room to move the control as much as is required? How fast does the control have to be moved? Can the operator move that fast?

4. Have you provided proper body support?

5. Is the direction of movement correct? Do you push forward to go forward? Do you push up to increase speed? Do you have S-R compatibility?

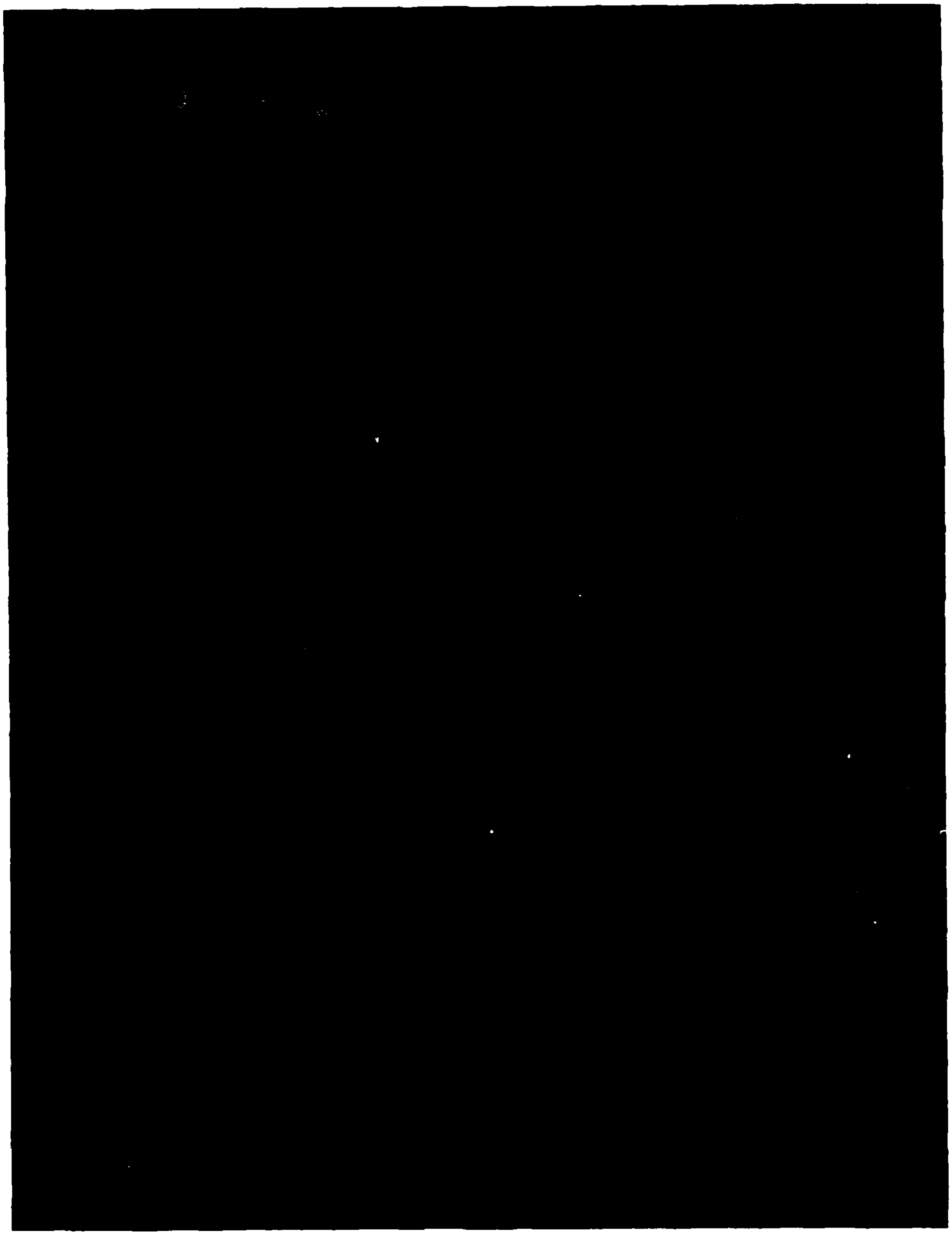
6. Are the control-display ratios correct? Is the ratio of movement of the control device to the movement of the display indicator compatible? As you turn the control dial, does the display indicator move the amount expected?

7. Is the control correctly coded? Have you used the accepted coding techniques (color, location, labeling, shape, and size) properly? Did you use red for emergency? Are controls which are used sequentially located close to one another?

8. Have you considered environmental factors? Can the operator utilize his equipment if he has heavy clothing on, or if he's sweating?

HUMAN FACTORS ENGINEERING INSTRUMENTATION PACKAGE

ENGINEERING FOR HUMAN USE



HUMAN FACTORS INSTRUMENTATION PACKAGE

BACKGROUND

This brochure describes the Human Factors Engineering Field Instrumentation Package supplied by Perceptronics, Inc. The package contains an integrated set of specialized instruments for human factors measurement, and an operation manual specifically directed towards human factors data acquisition. The purpose of the Field Instrumentation Package is to provide appropriate instrumentation for human factors evaluation in a compact, transportable, easy-to-use form. Instruments and accessories are stored in rugged carrying cases designed for protection and security during shipment, usage, and storage. The field instrumentation concept was originally developed by Perceptronics under contract to the U.S. Army Test and Evaluation Command Headquarters, Aberdeen Proving Ground, MD.

HUMAN FACTORS EVALUATION

The military has long recognized the need for Human Factors Engineering. In fact, current U.S. military regulations require that Human Factors Engineering (HFE) inputs be provided during the entire process of research, development, testing and evaluation. The concept of the transportable instrumentation package has been utilized in military development testing of new materiel for six years now, and has enjoyed a great deal of success.

Although the instrumentation package was designed for military application, it is perfectly suited to educational and industrial applications as well. Educational institutions have expressed the need for hands-on training for Human Factors instrumentation that students will eventually use outside the academic environment. Courses can be developed around the package that apply a combination of theory with operational usage. Two such applications to the industrial environment are: (1) equipment and workplace measurements, and (2) human factors design specifications. Examples of measurement in the workplace can involve measuring the airflow from a vent, determining the ambient temperatures given off by a room full of machines, assessing the noise levels of the same machines, etc. This application can help a company satisfy the ever increasing requirements of the Occupational Health and Safety standards. Examples of human factors design application may involve determining how much force is required to step on a brake pedal, assessing reach envelope characteristics, discovering annoying glare sources, etc. These are just a few of the multitude of uses the Human Factors Instrumentation Package can conveniently provide. The Application Guide on the following page illustrates more uses of the HFE package.

PACKAGE DESCRIPTION

There are 17 instrument groups in the basic package, covering the full range of measurement areas required in human factors engineering measurement. These measurement areas have been classified into 6 categories as follows:

Measurement Categories

(1) Ambient Environment. Air, water, surface temperatures, air movement, humidity, wind speed and direction, etc.

(2) Equipment and Workplace. Noise, illumination, glare, operating forces, dimension, etc.

(3) Task Performance. Procedures, task times, error frequency, event recording, report documentation, etc.

(4) Operator Characteristics. Height, weight, body dimensions, reach envelope, percentile designation, etc.

APPLICATION GUIDE

MEASUREMENT	EVALUATION AREA					
	PHYSICAL OPERATING ENVIRONMENT	DISPLAYS AND COMMUNICATION	CONTROLS	WORKSPACE	INGRESS/EGRESS	SAFETY
SOUND	Wide Band Noise Octave Band Analysis Impulse Noise	Articulation Index Signal/Noise Radio Filtering Characteristics		Wide Band Noise Octave Band Analysis Impulse Noise Reverberation Time		Maximum dB
VIBRATION	1/3 Octave Band Analysis Peak Shock Whole Body Vibration	1/3 Octave Band Analysis	1/3 Octave Band Analysis Peak Shock			Unsafe Vibration Levels
VISIBILITY	Illumination Level Glare	Luminance Level Illumination Level Contrast Ratio Background Brightness	Luminance Level Contrast	Illumination Level Glare Surround Brightness	Illumination Level Luminance Level	
ATMOSPHERIC ENVIRONMENT	Air, Water, Surface Temperature Humidity Barometric Pressure Wind Speed and Direction		Surface Temperature	Air Temperature Humidity Air Flow Surface Temperature		Extreme High/Low Surface and Air Temperatures Poor Ventilation
NOXIOUS GASES	Gaseous Vehicle Emissions Gaseous Gunfire/Rocket Fire Products			Gaseous Vehicle Emissions Gaseous Gunfire/Rocket Fire Products		Gaseous Toxic Hazards
FORCE AND DIMENSION		Display Size Visual Angle Distance to User	Control Force and Torque Replacements Clearances Control/Display Ratio	Physical Dimensions Angles Force Requirements and Torque	Dimensions of routes and Escape Routes Door/Hatch Handle Actuation Source Requirements	Lift Limits Emergency Reach Requirements Emergency Exit Requirements
ANTHROPOMETRY		Field of View	Operator Physical Characteristics (Anthropometric Measurements)	Operator Physical Characteristics (Anthropometric Measurements)	Operator Physical Characteristics (Anthropometric Measurements)	
PERFORMANCE	Effects of Environment on Performance	Missed Signals Frequency of Use Observer Comments Signal Rate Signal Duration Comissive/Omissive Errors	Inadvertent Operation Frequency of Use Time Lag	Time and Motion Study	Emergency Exit Time Exit Procedures	Emergency Procedures Incidents Accidents

(5) Recording and Analysis. Basic input signals, meter readings, interview data, statistical computation, etc.

(6) Maintenance and Support. Tool kit, test meter, battery charger, and tripods.

The various instruments in the basic package reflect a careful consideration of portability, usability, range, accuracy, reliability, ruggedness, and cost, so that the package achieves an optimum balance for general human factors applications. However, there are specialized instruments available as alternatives, and options that can supplement the basic package. Instruments can be provided that are specifically tailored to focus more intensely on any particular human factors measurement area as required by the user. A listing of the basic package instrumentation and accessories is provided on the following page.

INSTRUMENT PACKAGING

Instruments in the HFE Field Instrumentation Package are provided in a series of custom cases. These cases are constructed of lightweight, durable aluminum. They are foam lined and each instrument is custom fitted. The cases are each provided with a lock for secure storage. Instruments are packaged in groups according to the measurement areas in which they will be used. This common grouping allows the human factors specialist to take only those cases that are applicable to the particular testing activity taking place. In addition, the custom cases allow the human factors specialist to determine if all the instruments are collected after a field test by a quick visual inventory. Multi-use cases also are provided that make it possible for the specialist to assemble unique instrument groupings for specific measurement functions.

INSTRUMENTATION LISTING
(BASIC PACKAGE)

	MEASUREMENT AREA	INSTRUMENT	COMPONENTS AND ACCESSORIES	MANUFACTURERS/ DISTRIBUTOR
1	NOISE & VIBRATION	SOUND LEVEL METER/ANALYZER	MICROPHONES, ACOUSTIC CALIBRATOR, OCTAVE FILTER, WINDSCREEN, CABLES, BATTERIES	BRUEL AND KJAER
		VIBRATION KIT	(USED IN CONJUNCTION WITH B&K SOUND LEVEL METER/ANALYZER). THIRD OCTAVE FILTER, ACCELEROMETER, INTEGRATOR	
2	ILLUMINATION & BRIGHTNESS	PHOTOMETER/ SPOT BRIGHTNESS METER	ZEROING DISK, COSINE RECEPTOR, SPACE BATTERY, CARRYING CASE	PHOTO RESEARCH
3	FORCE & DIMENSION	FORCE, TORQUE AND DIMENSION KIT	DIAL PUSH/PULL GAUGES (2 lb, 5 lb, 50 lb, 250 lb) DIAL TORQUE GUAGE (5 in lb, 10 in lb, 20 ft lb, 160 ft lb) TORQUE ADAPTER ACCESSORIES, TAPES (12 ft, 20 ft, 100 ft, DIAL CALIPERS, PROTRACTORS	CHATTILLON CONSOLIDATED DEVICES, INC.
4	ATMOSPHERIC/ ENVIRONMENT	SLING PSYCHROMETER	SPARE WICKS, CARRYING CASE NO BATTERIES REQUIRED	WEATHER MEASURE
		WINDSPEED AND DIRECTION INDICATOR	NO BATTERIES REQUIRED	KAHL SCIENTIFIC
		ASPIRATING PSYCHROMETER	PSYCHROMETRIC SLIDE RULE, BATTERIES	WEATHER MEASURE
		DIGITAL THERMOMETER	AIR, SURFACE, LIQUID PROBES, AC ADAPTER AND CHARGER	COLE PARMER
		ANEMOMETER	PROBE, PROBE COVER, CABLE, CASE	KURZ
5	POLLUTANTS	UNIVERSAL GAS TESTER	DETECTION TUBES, REMOTE SAMPLING PUMP, CARRY CASE, SPARE PARTS	MINE SAFETY APPLIANCE
		SAMPLER	FILTER PAPER HOLDER, MIDGET IMPINGER, BATTERY CHARGER, CARRYING CASE	
6	ANTHROPOMETRY	ANTHROPOMETRY KIT	ANTHROPOMETER, SLIDING CALIPERS, SPREADING CALIPERS, GONIOMETER, TAPE MEASURE, ELECTRONIC WEIGHT SCALE	SIBER PRECISION SEARS
7	PERFORMANCE	ELECTRONIC STOPWATCH	3 STOP WATCHES	CRONUS
		POLAROID CAMERA	NORMAL LENS, WIDE ANGLE LENS, TELEPHOTO LENS, FILM PACK (COLOR, B&W, B&W NEGATIVE LIGHT METER ELECTRONIC FLASH	POLAROID
		VIDEOTAPE RECORDING SYSTEM	COLOR ZOOM CAMERA, VIDEO CASSETTE RECORDER, COLOR MONITOR, BATTERY PACKS, CABLES, CAR BATTERY ADAPTER, BATTERY CHARGER	JVC, SONY
8	RECORDING & ANALYSIS	AUDIO TAPE RECORDER	CASSETTE, REMOTE MIC WITH PAUSE, INTERNAL MIC, EAR PHONE, AC ADAPTER CHARGER, CARRYING CASE	SONY
		SCIENTIFIC CALCULATOR	THERMAL PRINTER/PLOTTER, MASTER LIBRARY, STATISTICS LIBRARY, OPERATION MANUALS, AC ADAPTER CHARGER, VINYL CASE	TEXAS INSTRUMENTS
		CHART RECORDER	BATTERY CHARGER, CHART PAPER	BREULAND KJEAR
9	MAINTENANCE & SUPPORT	TOOL KIT	ELECTRICIANS ASSORTED TOOL KIT	JENSON TOOLS
		DIGITAL TEST METER	TEST LEADS, CARRYING CASE, AUDIO FEEDBACK	WESTON
		BATTERY CHARGER	SELF CONTAINED UNIT	GENERAL ELECTRIC CO.
		TRIPODS	ONE HEAVY DUTY TRIPOD, ONE LIGHTWEIGHT VERSATILE TRIPOD	STAR-D VIVITAR

OPERATION MANUAL

The Operation Manual provides general guidelines for instrument use as well as specific instructions for set-up and operation. Each instrument referenced in the manual includes the following information:

(1) DESCRIPTION of the instrument and accessories.
(2) APPLICATION to HFE evaluation.
(3) SET-UP AND STORAGE procedures.
(4) OPERATION in step-by-step form for major types of use.
(5) REFERENCES to the HFE literature and other relevant documents.

Guidelines for periodic maintenance, calibration, and troubleshooting procedures are also provided. Detailed manufacturer's operating and service data are bound separately.

INSTRUMENT GROUPS

AMBIENT ENVIRONMENT (PPN-HFE-AE-100)

Portable Weather Check (PPN-HFE-AE-110)

A quick indication of weather condition is provided by the sling psychrometer and the wind speed and direction indicator. Rapid measurements of temperature, humidity, wind speed, and direction can be obtained. No batteries or external power required.

Aspirating Psychrometer (PPN-HFE-AE-120)

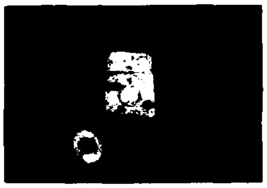
A measurement of relative humidity is obtained using the wet and dry bulb thermometer method. A small internal fan blows air over the wet bulb thermometer to obtain wet bulb measurements. Humidity measures are calculated using the enclosed conversion chart.

Digital Thermometer (PPN-HFE-AE-130)

Measures air, surface, or liquid temperatures from -22.0°F to 122.0°F (-30.0°C to +50.0°C) and +32.0°F to 199.0°F (0.0°C to +100°C). The thermometer has a liquid crystal display and a analog output for recording. Operates off batteries or online current.

Pollutants (PPN-HFE-AE-140)

Kit contains gas tester and a Sampling Pump. The gas tester is for short term sampling and evaluation of toxic gases and fumes. The sampling pump provides for long-term sampling of gases, vapors, and dust in the work surround.



Hot Wire Anemometer (PPN-HFE-AE-150)

Measures local air flow in either feet per minute (FPM) or meters per second (MPS). Lower range reads 0-200 FPM or 0-1 MPS and the upper range reads 0-1000 FPM or 0-5 MPS. Battery powered with up to ten hours of operation.

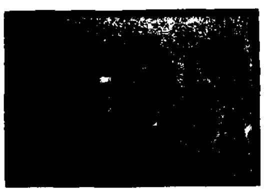
EQUIPMENT AND WORK PLACE (PPN-HFE-EW-200)

Sound Level Meter/Analyzer (PPN-HFE-EW-210)

Measures sound in the range of 0 to 80 KHz for the standard weighting curves (A, B, and C). It measures impulse noise from 79 to 170 dB with a peak hold feature. Meter doubles as a vibration meter/analyzer when used in conjunction with the vibration kit.

Vibration Kit (PPN-HFE-EW-220)

The vibration kit contains a single axias accelerometer, a triaxial accelerometer, an integrator, and a 1/3 octave band analyzer. Measures of acceleration, velocity, and displacement can be made. This kit is to be used with the above sound level meter/analyzer.



Photometer/Spot Brightness Meter (PPN-HFE-EW-230)

A compact photometric system combining photometry with spot brightness. Measures from .01 to 19,990 footcandles and foot-lamberts. It has a 1° acceptance angle. This system also includes a fiber optic probe and a micro-reader.

Force, Torque, and Dimension Kit (PPN-HFE-EW-240)

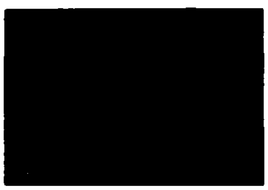
Provides a wide variety of instruments for measuring forces, torques, and dimensions. Force measurements can be made from 1/4 inch-ounces to 250 foot-pounds. Torque measurements range from .05 inch-pounds to 160 foot-pounds. Dimensional and angular measurements can be made with this kit. Accessories are provided for various torque measurement applications.

<u>TASK PERFORMANCE</u> (PPN-HFE-TP-300)

Timers (PPN-HFE-TP-310)

Measurement of elapsed time is made with an electronic stopwatch. This timer incorporates time-out timing, split/cumulative timing, and Taylor-sequential timing of up to four intervals plus elapsed time. Time is read from a liquid crystal display. Three timers are provided.

Videotape System (PPN-HFE-TP-320)



Recording and analysis of ongoing performance is done with this videotape system. The system consists of a vidicon tube color camera with zoom lens with 1.5 inch CRT monitor/viewfinder, a portable videotape recorder, and an AC or battery-powered 8" color monitor. The camera features low light operation, automatic exposure control and a built-in microphone.

Polaroid Camera System (PPN-HFE-TP-330)

Permanent photographic records of events are made with immediate feedback using the Polaroid 600 SR professional camera. Includes standard, wide angle, and telephoto lens. Removable film pack accommodates a variety of film types (i.e., color and black and white). System includes a light meter and electronic flash.

OPERATOR CHARACTERISTICS (PPN-HFE-OC-400)

Anthropometry Kit (PPN-HFE-OC-400)

Provides for measurement of major body dimensions. Includes a precision anthropometer, spreading calipers, sliding calipers, goniometer, spreading calipers, sliding calipers, goniometer, and measuring tapes. The kit is contained in a padded carrying bag. Also included in a digital weight scale for measures of human or object weight.

RECORDING AND ANALYSIS (PPN-HFE-RA-500)

Audio Tape Recorder (PPN-HFE-RA-510)

A small high-fidelity cassette recorder used for documenting interviews. Uses standard cassettes giving a range of 30 to 120 minutes recording time. Includes a built in microphone, a remote pause switch microphone, and an earphone.

Calculator System (PPN-HFE-RA-520)

This is a very powerful and versatile calculating system. It has a 12 character LED display; it's programmable with up to 960 program steps; it has 100 data registers, and features fixed or floating decimal point. The calculator uses magnetic cards, included is a master library and a statistical package. The system also includes a thermal printer/plotter.

Chart Recorder (PPN-HFE-RA-530)

Provides for a hardcopy readout for such areas as sound analysis, vibration analysis, displaying temperature, etc. Features logrithmic plotting capacity, special paper options and a magnetic needle support.

MAINTENANCE AND SUPPORT (PPN-HFE-MS-600)

Tool Kit (PPN-HFE-MS-610)

Electricians tool kit provides all equipment necessary for routine maintenance of electronic instruments and other equipment in the HFE package.

Digital Test Meter (PPN-HFE-MS-620)

Measures DC and AC volts, DC and AC current, and resistance. The primary use of this instrument is to aid in the setup, routine maintenance, calibration, and service package instruments. Secondarily, it serves as a display device for data recording and analysis functions.

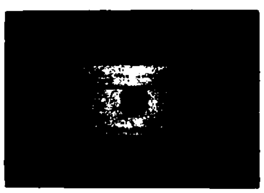
Battery Charger (PPN-HFE-MS-630)

Recharges AA, C, and D size nicad batteries required for the sound level meter, hotwire anemometer, and aspirating psychrometer. Contains a overcharge protection feature.

Tripods (PPN-HFE-MS-640)

The package contains two tripods--one heavy duty and one lightweight. The heavy duty tripod is used for all heavy duty applications, such as video taping. Greater flexibility can be obtained with the lightweight tripod which has thumb release 0 and 90° extension legs.

PACKAGING (PPN-HFE-P)



Aluminum Case--Front View

The cases are made of light weight, but strong and durable, aluminum construction. They come in various sizes depending on the size and/or the number of components contained within a instrument system.

Aluminum Case--Custom

Instruments are custom fitted in foam.

Aluminum Case--Multi-Use

Extra cases (2) are provided with foam inserts for field carry of miscellaneous instruments and components.

Field Camera Case

A flexible camera bag with shoulder strap is provided for field use.

ALTERNATIVES AND OPTIONS

Alternatives and options can be substituted for basic package instruments or added to basic package instruments where individual measurement requirements dictate. For instance, one customer had specific measurement requirements in the recording and analysis category and we provided a micro-computer system which is described below:

Micro-Computer System

The system includes a microprocessor, two floppy disc drives, a printer, and a portable color monitor. The microprocessor has 48K random access memory with both floating point and integer basic. Vast potential of application: data recording and statistical analysis, experimental control word processing, simulation, etc.

If you have more specific human factors measurement requirements which are not met by the basic package instruments, we can provide the best available instruments at an optimal cost-to-benefit ratio to accommodate your needs.

ORDERING INFORMATION FOR BIBLIOGRAPHIC AND REFERENCE MATERIAL

1. Government technical reports can be ordered from:

    Defense Technical Information Center
    Cameron Station
    Alexandria, VA 22314

2. Military standards, specifications, and handbooks can be ordered from:

    Commanding Officer
    Naval Publications and Forms Center
    5801 Tabor Avenue
    Philadelphia, PA 19120

Army installations will use DA Form 17 to place their orders. Other services should check with publications and forms personnel and secure the proper ordering form.

3. Books and journal articles can be secured from the appropriate publishers and journals.

REFERENCES

AR 602-1. Personnel-materiel systems human factors engineering program. Headquarters, Department of the Army, Washington, DC, 1980.

ASHRAE. Handbook of fundamentals. Ashrae, NY, 1967.

Bradley, J. V. Tactual coding of cylindrical knobs. Human Factors, 1967, 9(5), 483-496.

Brown, D. B. Systems analysis and design for safety. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1976.

Chambers, R. M. Operator performance in acceleration environments. In N. M. Burns, R. M. Chambers, & E. Hendler (Eds.), Unusual environments and human behavior. New York: The Free Press, 1963, 193-320.

DeGreene, K. B. Systems psychology. New York: McGraw-Hill, 1970.

Harris, C. M. (Ed.). Handbook of noise control. New York: McGraw-Hill, 1957.

HEL TM 29-76 (See Berson, B. L. & Crooks, W. H.)

Johnson, S. L., & Roscoe, S. N. What moves, the airplane or the world? Human Factors, 1972, 14(2), 107-129.

Kelley, C. R. Manual and automatic control. New York: John Wiley & Sons, 1968.

Kennedy, K. W. International anthropometric variability and its effect on aircraft cockpit design. In Chapanis, A. (Ed.).

Landy, F. J., & Trumbo, D. A. Psychology of work behavior. Homewood, Ill: The Dorsey Press, 1976.

Langham, W. H. (Ed.). Radiobiological factors in manned space flight. Publication 1487. Washington, DC: National Academy of Sciences National Research Council, 1967.

McCormick, E. J. Human factors in engineering and design (4th ed.). New York: McGraw-Hill, 1976.

Meister, D., & Rabideau, G. F. Human factors evaluation in system development. New York: John Wiley & Sons, 1965.

Miller, G. A. The magical number seven, plus or minus two: Some limits on our capacity for processing information. Psychology Review, 1956, 63, 81-97.

MIL-H-46855. Human engineering requirements for military systems, equipment and facilities. January 1979.

MIL-HDBK-759. Human factors engineering design for army materiel. March 1975.

MIL-STD-721. Definitions of effectiveness terms for reliability, maintainability, human factors, and safety. August 1966.

MIL-STD-1472. Human engineering design criteria for military systems, equipment and facilities. December 1974.

MIL-STD-1474. Noise limits for army materiel. March 1975.

Oatman, L. C. Check-reading accuracy using an extended-pointer dial display. Journal of Engineering Psychology, 1964, 3, 123-131.

Parker, J. F., & West, V. R. (Eds.). Bioastronautics data book. National Aeronautics and Space Administration, Washington, DC, 1973.

Peters, G. A., & Adams, B. B. These three criteria for readable panel markings. Product Engineering, 1959, 30(21), 55-57.

Peterson, A. P. G., & Gross, E. E., Jr. Handbook of noise measurement (7th ed.). New Concord, MA: General Radio Co., 1972.

Siple, P. A., & Passel, C. F. Measurement of dry atmospheric cooling in subfreezing temperature. Proceedings of the American Philosophical Society, 1945, 89, 177-199.

Taylor, F. V. Psychology and the design of machines. The American Psychologist, 1957, 12, 249-258.

Tomlinson, R. W. Estimation and reduction or risk of hearing: The background and a case study. Applied Ergonomics, 1971, 2(2), 112-119.

Van Cott, H. P., & Kinkade, R. G. Human engineering guide to equipment design (Rev. ed.). Washington, DC: US Government Printing Office, 1972.

Wegel, R. L., & Lane, C. E. The auditory masking of one pure tone by another and its probable relation to the dynamics of the inner ear. Physiological Review, 1924, 23, 266-285.

Woodson, W. E., & Conover, D. W. Human engineering guide for equipment designers (2d ed.). Berkeley, CA: University of California Press, 1966.

BIBLIOGRAPHY

Alluisi, E. A., Coates, G. D., & Morgan, B. B., Jr. Effects of temporal stressors on vigilance and information processing. Vigilance: Theory, operational performance and physiological correlates, Robert R. Mackie (Ed.). New York: Plenum Press, 1977.

Berson, B. L., & Crooks, W. H. Guide for obtaining and analyzing human performance data in a materiel development project (Technical Memorandum 29-76). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, 1976.

Brauneck, T. W., Miles, J. L., Jr., & Kibler, R. J. Relating target visibility factors to small arms combat effectiveness (Technical Memorandum 17-76). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, 1976.

Coscio, W. Applied psychology in management. Reston, VA: Reston Publishing Co., 1978.

Chambers, R. M., & Brown, J. L. Acceleration. Symposium on Environmental Stress and Human Performance, American Psychologiccal Association, September 1969.

Chapanis, A. Research techniques in human engineering. Baltimore: The Johns Hopkins Press, 1959.

Crawford, A. M., & Crawford, K. S. Simulation of operational equipment with a computer-based instructional system: A low cost training technology. Human Factors, 1978, 20(2), 215-225.

Cunningham, C. E., & Cox, W. Applied maintainability engineering. New York: John Eiley, 1972.

D'Amato, M. R. Experimental psychology: Methodology, psychophysics and learning. New York: McGraw-Hill, 1970.

DARCOM/TRADOC. Training acquisition handbook. December, 1979.

Deatherage, B. H. Auditory and other sensory forms of information presentation. In H. P. Van Cott & R. G. Kinkade (Eds.), Human engineering guide to equipment design (rev. ed.). Washington, DC: US Government Printing Office, 1972.

Eldred, K. M., Gannon, W. J., & von Gierke, H. Criteria for short time exposure of personnel to high intensity jet aircraft noise (Report No. WWADC-TN-55-355). Wright-Patterson AFB, OH: Wright Air Development Center, 1955.

Fitts, P. M., & Jones, R. E. Analysis of factors contributing to 460 "pilot error" experiences in operating aircraft controls. In H. W. Sinaiko (Ed.), Selected papers on human factors in the design and use of control systems. New York: Dover Publications, Inc., 1961.

Fitts, P. M., & Jones, R. E. Psychological aspects of instrument display. I. Analysis of 270 "pilot error" experiences in reading and interpreting aircraft instruments. In H. W. Sinaiko (Ed.), Selected papers on human factors in the design and use of control systems. New York: Dover Publications, Inc., 1961.

Goldman, A. S., & Stattery, T. B. Maintainability: A major element of system effectiveness. New York: John Wiley, 1964.

Guide for conservation of hearing in noise. Subcommittee on Noise, American Academy of Ophthalmology and Otolaryngology, revised 1964.

Goldstein, I. I. Training: Program development and evaluation. Monterey, CA: Brooks/Cole Publishing Co., 1974.

Helm, W. R., & Donnell, M. L. Mission operability assessment technique: A system evaluation methodology (Technical publication TP-79-31). Point Mugu, CA: Pacific Missile Test Center, October 1979.

Holshouser, E. L. Guide to human factors engineering general purpose test planning (GPTP). Point Mugu, CA: Pacific Missile Test Center, June 1977.

Howell, W. C., & Goldstein, I. L. Engineering psychology: Current perspectives in research. New York: Appleton-Century-Crofts, 1971.

Human factors engineering technology for ships program plan. Naval Sea Systems Command, June 1979.

Human factors for designers of naval equipment. Volumes I and II, 1971.

Human factors test and evaluation manual, Volumes I, II, III. HFTEMAN support data (TP-76-11). Point Mugu, CA: Pacific Missile Test Center, October 1976.

Industrial noise manual (2nd ed.). Detroit: American Industrial Hygiene Association, 1966.

Kaplan, J. D., & Crooks, W. H. A concept for developing human performance specifications (Technical report PTR-2020-80-3). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, 1980.

Katznelson, J. A computer program for assessing readability (Technical Memorandum 4-80). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, 1980.

Kling, J. W., & Riggs, L. A. Sensation and perception. In Woodworth & Schlosberg (Eds.), Experimental psychology (Vol. I) (3rd ed.). New York: Holt, Rinehart, and Winston, Inc., 1972.

Laumets, E. Time history of biological response to ionizing radiation (USNR DL-TR-905). San Francisco: Naval Radiological Defense Laboratory, 1965

Layout of panels and machines, applied ergonomics handbook. Chapter 5 in Applied Ergonomics, 1970, 1(2), 107-112.

Martin, M. D. Standardization of visual tasks and measures (Technical Note 2-73). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, 1973.

Meister, D. Human factors: Theory and practice. New York: John Wiley & Sons, 1976.

Meister, D. Behavioral foundations of system development. New York: John Wiley & Sons, 1976.

Murrell, K. F. H. Human performance in industry. New York: Reinhold Publishing Corp., 1965.

Nancy Manager's guide for the test and evaluation sections of MIL-H-46855. Warminster, PA: Naval Air Development Center, June 30, 1977.

Neale, J. M., & Liebert, R. M. Science and behavior: An introduction to methods of research. Englewood Cliffs, NJ: Prentice-Hall, 1973.

Personnel Subsystems, USAF. AFSC design handbook, Series 1-0 (General AFSC DH 1-3) (1st ed.). Headquarters, AFSC, January 1969.

Roscoe, J. T. Fundamental research statistics for the behavioral sciences. New York: Holt, Rinehart and Winston, Inc., 1975.

Shephard, R. J. Men at work: Applications of ergonomics to performance and design. Springfield, IL: Charles C. Thomas, 1974.

Siegel, A. T., & Wolf, J. J. Man-machine simulation models: Psychosocial and performance interaction. New York: John Wiley & Sons, Inc., 1969.

Sinaiko, H. W. (Ed.). Selected papers on human factors in the design and use of control systems. New York: Dover Publications, Inc., 1961.

Steinberg, S. A computer model for evaluating the effects on fighting vehicle crew members of exposure to carbon monoxide emissions (Technical Note 1-80). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, 1980.

Steinberg, S., & Nielson, G. D. A proposal for evaluating human exposure to carbon monoxide contamination in military vehicles (Technical Memorandum 11-77). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, 1977.

US Army Headquarters. Personnel-materiel systems: Human factors engineering program (Army Regulation 602-1). Washington, DC: Author, June 1976.

US Army Headquarters. Job and task analysis (TRADOC Reg. 351-4). Fort Monroe, VA: US Army Training and Doctrine Command, March 1979.

US Army Headquarters. Job and task analysis (TRADOC Pam. 351-4. Fort Monroe, VA: US Army Training and Doctrine Command, August 1979.

US Army Ordnance. An introduction to human engineering (Technical Memorandum 9). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, 1954.

US Army Ordnance Missile Command. Maintainability design factors. Redstone Arsenal, AL, 1961.

US Army Test and Evaluation Command. Common engineering test procedure: Human factors engineering (vehicle) (Material Test Procedure 2-2-803). Aberdeen Proving Ground, MD, August 1966.

Verdier, P. A. Basic human factors for engineers. New York: Exposition Press, 1960.

NOTES

☆ U.S. GOVERNMENT PRINTING OFFICE : 1962 O - 370-087 (Vol.3)

END

DATE
FILMED

9 83

DT